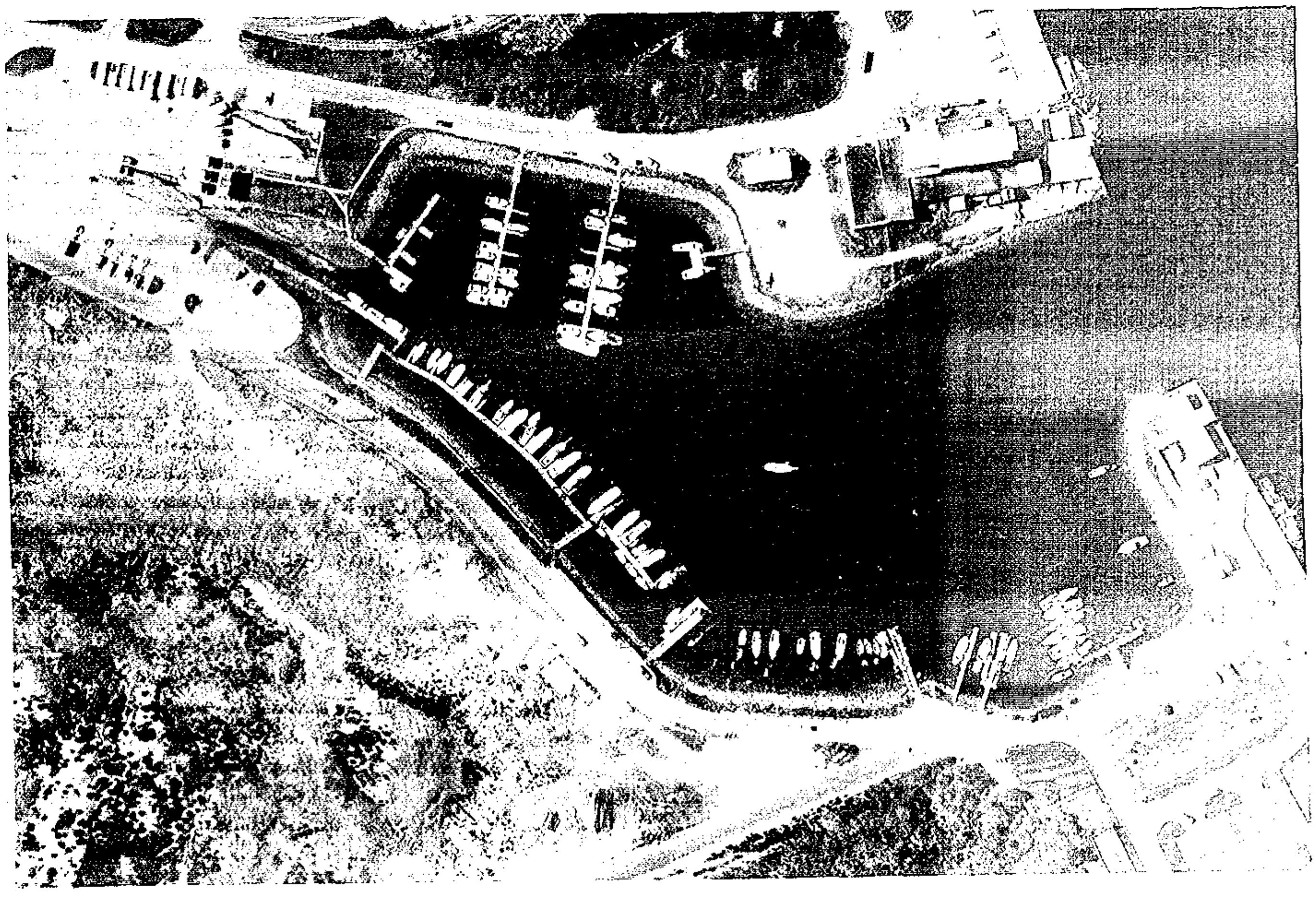
Supporting Documentation

East Boat Basin
Cape Cod Canal
Sandwich, Massachusetts



US Army Corps of Engineers
New England Division

EAST BOAT BASIN
CAPE COD CANAL
SANDWICH, MASSACHUSETTS

SUPPORTING DOCUMENTATION

SECTION 1 - ENGINEERING

SECTION 2 - ECONOMICS

Prepared by the
New England Division, Corps of Engineers
Department of the Army

SECTION 1

ENGINEERING

ENGINEERING

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ENGINEERING

This section of the supporting documentation contains the engineering data that was developed for the formulation and evaluation of alternative plans. Engineering input included navigation system design, subsurface investigations, quantity and cost estimates, and boat storage analyses.

NAVIGATION SYSTEM DESIGN

In order to assure that alternative plans can adequately accommodate the various types of vessels expected to utilize an improved East Boat Basin in the future, a properly designed navigation system must be incorporated into the various plans. The navigation system proposed for the alternative plans include an entrance channel, a turning/maneuvering area, offloading areas and berthing areas. These navigation features must be properly sized to insure safe navigation. A set of standard channel design criteria was utilized for dimensioning the components of the navigation system. The dimensioning procedure was based on a "design vessel", which is representative of the most typical vessel expected to use the future basin. A typical vessel does not necessarily mean average vessel, but indicates the size of vessel expected to make the most use of the expanded East Boat Basin, based on present conditions and future potential of the fishing fleet.

DESIGN VESSEL

The first step in establishing proper dimensions for the various navigation features was to determine the design vessel. This was done by examining the vessels that presently offload along the bulkhead and that use the basin. Public interests were consulted to make reasonable projections of the types and sizes of vessels that are expected to use the basin in the future. Utilizing existing information and the input provided by public interests, a design vessel was established as a basis for determining proper dimensions.

Fishing vessels that presently offload along the bulkhead range in size from 30-140 feet in length, with 80-85 foot vessels being most typical. Within this range of vessels are the Sandwich based boats, which are typically 45-50 feet in length with several up to 60-70 feet in length. The homeport fleet represents roughly 25 percent of the total landings, with the remainder coming from transient vessels. The greater percentage of transient boats, which are generally larger than homeport vessels, causes the make-up of the fleet that offloads at Sandwich to be represented by a larger vessel (80'-85'). Therefore, the typical vessel offloading at Sandwich is a transient vessel.

Recreational vessels using the East Boat Basin reach a maximum length of about 50 feet, with the 25-40 foot range being most typical.

In order to determine the type and size of design vessel to be established, the following public inputs and resultant assumptions were considered.

a. The local fishermen feel that an expanded basin could accommodate vessels up to 80-85 feet in length, safely and efficiently.

b. Based on the type of future fishery that the National Marine Fisheries Service anticipates for the East Boat Basin, the vessels required for this fishery would range in size from 50-80 feet in length.

c. Provision of navigation facilities for large boats (100'-140'), was assumed to be not feasible. The two previous statements do not support an increase in the number of large boats. Since the larger class of boats comprise only a small percentage of the total fleet (New England fleet), the construction of navigation facilities for a few large boats would not be cost effective. The opportunity for large boats to offload at the Sandwich bulkhead would remain, while retaining their present homeport at a larger fishing port.

d. Several other regional ports are also experiencing overcrowding. Therefore a large number of transfer vessels are expected to find a new homeport at Sandwich. The bulk of these vessels are expected to be of the workhorse class vessel of 70-90 feet in length, fishing for groundfish.

e. As previously discussed, the typical vessel presently offloading at Sandwich is an 80-85 foot transient vessel. A basin expansion plan should provide access for this class of vessel to the basin, in order to provide additional offloading opportunities or to obtain marine services.

f. Recreational boat sizes are expected to remain relatively constant. Also recreational boat sizes are substantially smaller than fishing craft and are not expected to impact the design of co-use navigation facilities.

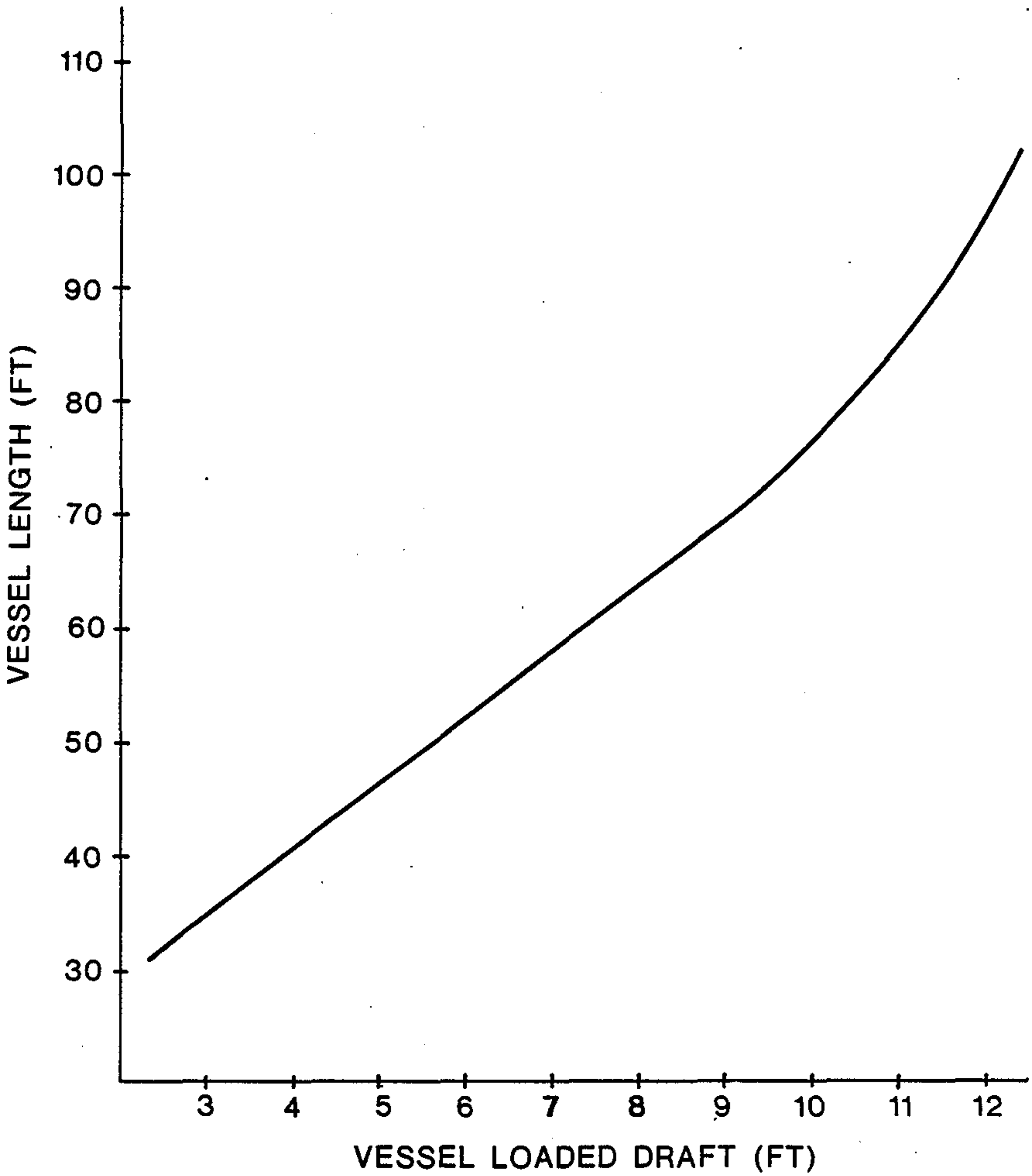
Based on the above information, a typical vessel of 80 feet in length was selected as the design vessel for determination of navigation system dimensions.

In order to determine the appropriate beam and loaded draft dimensions of an 80-foot long vessel, and to provide data for other boat sizes, a survey was made of recently constructed fishing boats. The survey information was obtained from a number of issues of <u>The National Fisherman</u> periodical. Figures 1-1 and 1-2 were developed from the survey. The dimensions for an 80-foot long fishing vessel are provided below.

Length - 80 feet

Beam - 23 feet

Loaded Draft - 11 feet



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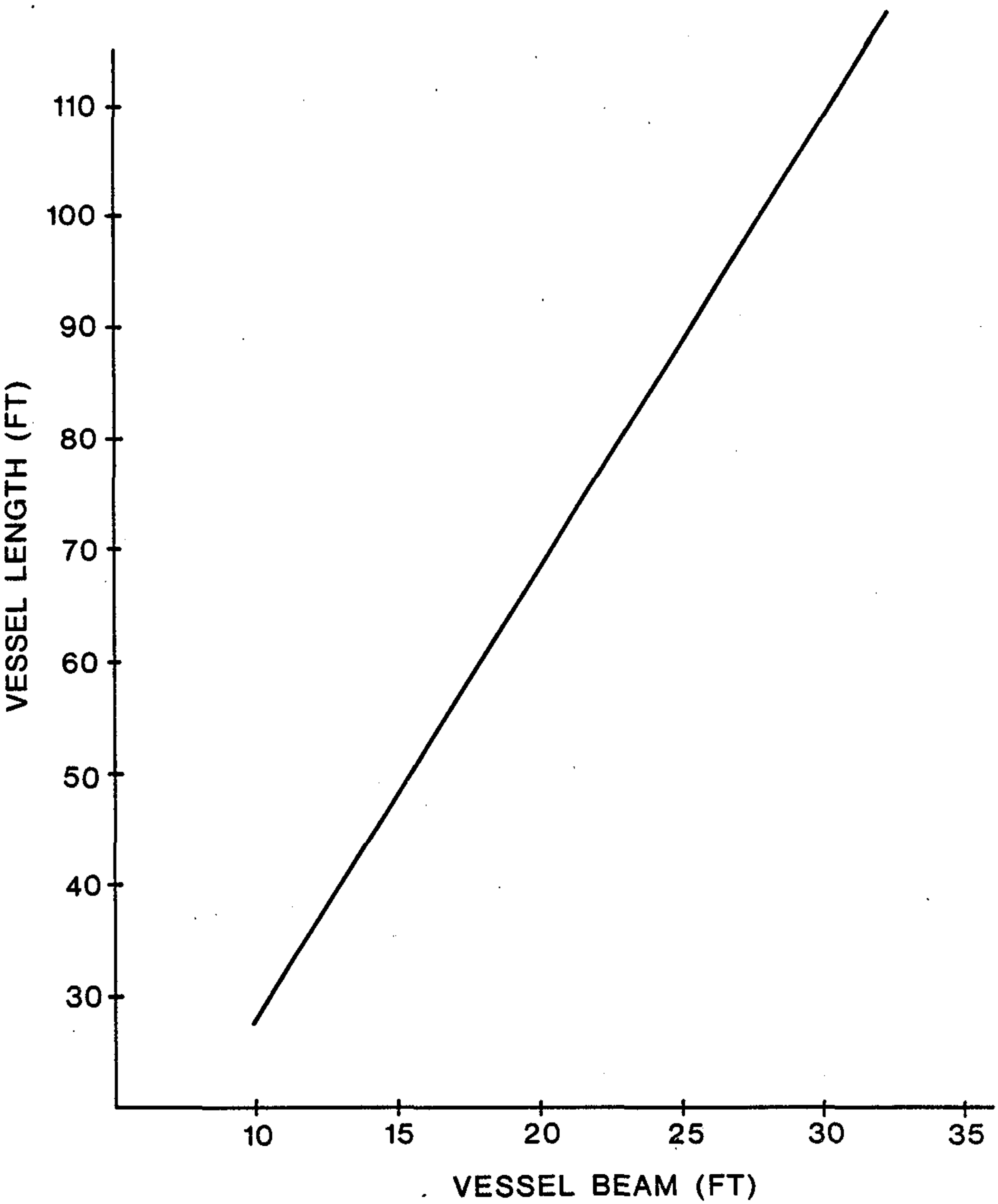
SANDWICH, MASSACHUSETTS
WATER RESOURCES IMPROVEMENT STUDY
LENGTH-DRAFT CURVE

FIGURE 1-1



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LENGTH-BEAM CURVE

FIGURE 1-2

CHANNEL DESIGN

Channel design is required in order to insure safe and efficient navigation in a waterway. The major considerations in the design of channels are the provision of adequate depth and width.

Channel depths are measured from the mean low water datum. Prior to establishing maximum channel depths for the East Boat Basin, several tidal and related hydraulic phenomena were considered. These phenomena included static draft, squat, rolling and pitching, buoyancy loss and clearance. They are described below.

Static Draft - Static draft is the vertical distance from the water surface level to the lowest point of a non-moving boat or ship.

Squat - Squat is a phenomenon that causes a vessel to sink into the water because of its forward movement.

Rolling and Pitching - Rolling and pitching are movements of a vessel that occur because of wave action. Rolling occurs about a vessel's longitudinal axis and pitching occurs about a vessel's latitudinal axis.

Buoyancy Loss - Buoyancy loss occurs when less dense fresh water of a river mixes with the saline water of an ocean harbor. The resultant effect on vessels is an increase of draft due to the buoyancy reducing freshwater-saltwater mixture.

Clearance - Clearance is the allowance of additional depth under a vessel in order to avoid damage to propellers and rudders, prevent fouling of water intake pumps and avoid excessive displacement of bottom materials.

A maximum channel depth was designed in the following manner.

Vessel Static Draft	- 11 feet
Squat (nominal)	- 1 foot
Rolling and Pitching	- negligible, the basin is well protected
Buoyancy Loss	- negligible, no major sources of freshwater enter the basin
Clearance	- 2 feet
Maximum Design Channel Depth	- 14 feet below MLW

Channel width design can be performed for both one-way traffic and two-way traffic. Design of a two-way channel was chosen because of the expected high level of activity. Future activity will include permanent recreational boats entering and leaving the basin, commercial fishing boats entering and leaving the basin, the U.S. Coast Guard must frequently provide quick response for emergencies, the Corps of Engineers will use the basin periodically, and many transient sailboats utilize the basin during the summer. This level of activity would be extremely difficult to manage if a one-way traffic system was to be implemented.

The channel width design was based on the beam dimension of the design vessel. For two-way navigation a channel consists of two maneuvering lanes, two bank clearance lanes and a ship clearance lane. The dimension of each channel lane was determined by assigning a percentage of the vessel's beam, based on the type of navigation conditions that would be encountered. Three navigation conditions were analyzed in determining proper channel widths, including entering the basin, exiting the basin and navigating within the basin. Each condition is analyzed below.

1. Entering the Basin - When boats maneuver to enter the basin, they are subjected to broadside currents of the Cape Cod Canal. This results in poor vessel controllability due to drifting. A larger maneuvering lane was recommended to provide additional room for navigation error. Also, as a vessel enters the basin, the material beyond the channel limit will consist of riprap revetment, and slips will be located along the channel limit. Therefore, a large bank clearance lane was recommended.

2. Exiting the Basin - Boats leaving the basin receive minimal exposure to adverse navigation conditions (e.g. waves entering

the basin) giving vessels good controllability. A moderate maneuvering lane was recommended. The material beyond the channel limit when leaving the basin would also be riprap revetment or bulkhead at the channel line, therefore requiring a large bank clearance lane.

3. Within the Basin - The inner portion of the basin will be well protected, giving vessels excellent controllability. The least conservative maneuvering lane width was recommended. Alignment of the channel in the center of the basin will make yaw effects due to near-bank phenomena negligible. The channel will be well defined allowing navigation close to the edge of the channel. A bank clearance lane of minimal width was recommended.

The entrance channel width dimension was determined for two locations, at the basin entrance and within the basin, because of varying navigation conditions. Navigation at the basin entrance would be more hazardous than navigation within the basin. Therefore, the channel width established at the basin entrance was more conservative. It was based on a combination of the entering and exiting the basin conditions. The width of the inner portion of the channel was determined by doubling the within the basin condition. The ship clearance lane was 80 percent in all instances. Tables 1-1 and 1-2 summarize the determination of channel widths.

Table 1-1

Basin Entrance - Channel Width

	Percent of Beam		
Lane	Enter Basin	Exit Basin	Total
Maneuvering	200	180	380
Bank Clearance	150	150	300
Ship Clearance	-	-	80
Total			760

Channel width = 760% x 23 feet = 174.8 feet, Say 180 feet.

Table 1-2

Inner Basin - Channel Width

	Percent of Beam		
Lane	Inner Basin		Total
Maneuvering	160	x 2	320
Bank Clearance	60	x 2	120
Ship Clearance	80		80
Total			520

Channel width = 520% x 23 feet = 119.6 feet, Say 120 feet.

Based on the previous rationale and computations the entrance channel width selected for the basin entrance was 180 feet, transitioning to a width of 120 feet inside the basin.

TURNING/MANEUVERING AREA DESIGN

Turning/Maneuvering areas were incorporated into the various alternative plans to allow the maneuvering of vessels for offloading purposes, and for vessels to turn around in order to exit the basin. The standard design criteria used for establishing turning area dimensions calls for a trapezoidal area with a minimum dimension of 150 percent of the vessel length. A minimum trapezoid dimension of 200 percent of vessel length was selected for an expanded East Boat Basin because of the following reasons. Operations within an expanded basin will remain constricted, the 150 percent figure was based on tug-assisted ocean going vessels whereas smaller vessels do not utilize tug assistance, and larger vessels may occasionally enter the basin. The increased dimension will reduce problems that could develop due to the above conditions. Depths of turning/maneuvering areas were established at the same depth as navigation channels.

OFFLOADING AREAS

Offloading areas were estabished along certain areas of the shoreline where the offloading of fish would most likely occur for each particular plan. The beam dimension of the design vessel is 23 feet, therefore the offloading zone width was rounded to 30 feet, taking into account possible use by larger vessels. The depth of these areas are the same as for navigation channels.

BERTHING AREAS

Recreational boating and commercial fishing berthing areas were proposed for all plans. The depths of the berthing areas were based on the type and size of vessels expected to use them. The recreational boating berthing area depth was established at -8 feet MLW based on recommendation from the harbormaster. Depth for the commercial berthing area was established at -12 feet MLW. The channel system was designed to allow a fully loaded design vessel to transit the harbor at mean low water when returning from a fishing trip. However, when the vessel is unloaded it loses approximately two feet of draft. Therefore, the commercial berthing area need not be the same depth as the channel.

Existing basin berthing areas would remain at present depths of -8 feet MLW in the recreational area, and -13 feet MLW in the commercial area. The -8 foot MLW portion of the commercial area would be dredged to -12 feet MLW for Plans A and C, thereby keeping depths in the existing basin consistent with expanded area depths for flexibility of berthing arrangements.

REFERENCES

1. McAleer-Wicker-Johnston, Evaluation of Present State of Knowledge of Factors Affecting Tidal Hydraulics and Related Phenomena, Report No. 3, Chapter X, USAE Waterways Experiment Station, Vicksburg, Mississippi, 1965.

2. USAE, Tidal Hydraulics-Engineering and Design, EM 1110-2-1607, Office of the Chief of Engineers, Washington, D.C., 2 August 1965.

ENGINEERING INVESTIGATIONS, DESIGN AND QUANTITY ESTIMATES

Engineering investigations were undertaken to address project considerations concerning the engineering aspects of the proposed basin expansion. Field investigations and engineering analyses were performed to support design of project components for estimation of project costs.

FIELD INVESTIGATIONS

Topographic Surveys

The town of Sandwich performed a topographic survey of the town-owned property in 1978, the results of which are shown on Figure 4 in the main body of the Feasibility Report. Additional topographic information from previous reports was used to determine topography immediately surrounding the basin.

Hydrographic Surveys

The Corps of Engineers performed a hydrographic condition survey of the East Boat Basin on April 30, 1979. The hydrographic survey results are also shown on Figure 4 in the main body of the Feasibility Report. The plotted depths provide an accurate assessment of the harbor bottom at that time.

Subsurface Investigations

Subsurface field explorations were made during July 1981 for the performance of foundation analyses and environmental studies. The results of the field explorations and the findings of the foundation analyses concerning the landcut area are contained in the previous Slope Stability Investigation section. Chemical content test results and gradation curves were developed for environmental study samples taken from both the landcut area and the existing basin. They are contained in Appendix 1, Environmental of the Feasibility Report.

SLOPE STABILIZATION

Foundation analyses were performed to determine the stability of slopes subjected to conditions expected at an expanded East Boat Basin. They were performed to determine the steepest safe slope, given the need to maximize use of available space. Findings of the analyses indicate that a shore slope of 1 (vertical) on 2 (horizontal) would be stable, and was therefore adopted as the design slope for the project.

Underwater slopes between navigation features were assumed to stabilize at 1 (vertical) on 3 (horizontal). This slope is a standard assumption for normal harbor conditions, which generally contain more fines than the East Boat Basin. Therefore, the 1 on 3 slope assumption should be satisfactory since basin materials would tend to slump less than in typical harbors.

SHORELINE PROTECTION

Two shore protection methods were considered for implementation in a basin expansion project, riprap revetment and steel sheet bulkhead.

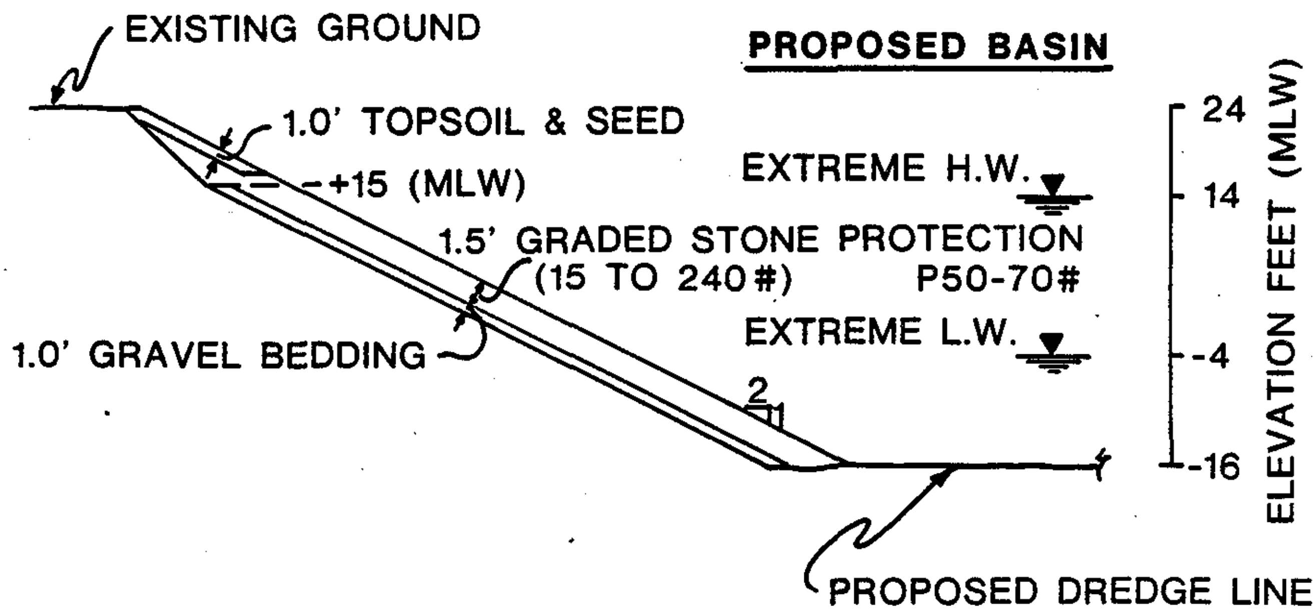
The excavation of slopes and placement of riprap revetment on them is substantially cheaper than the construction of bulkhead. Therefore, riprap was proposed for use around most of the expanded basin perimeter. A section of the design revetment slope is shown on Figure 1-3.

Steel sheet bulkheading was proposed for offloading areas to facilitate the offloading and servicing of fishing vessels. A bulkhead analysis was performed to develop cost estimates for construction of the bulkhead system. The design bulkhead section used for cost estimating is shown on Figure 1-4.

Top elevations for riprap revetment and bulkheading were set at 11 feet NGVD(about 15 feet MLW), effectively establishing the minimum elevation for onland development. This elevation was established based on national floodplain management policies, utilizing the 100-year flood elevation of 10.3 feet NGVD and rounding up. For purposes of the navigation project, slopes were carried back from the top of bulkhead and riprap slope to existing grade at 1 (vertical) on 2 (horizontal).

*ASSUMED MAX WAVE HEIGHT=2.0'

*SUBSURFACE EXPLORATIONS INDICATE THAT GROUNDWATER FLUCTUATES WITH THE TIDE AND WAS RECORDED BETWEEN ELEVATION 6.4 AND 14.2 FEET (MLW)



TYPICAL SECTION

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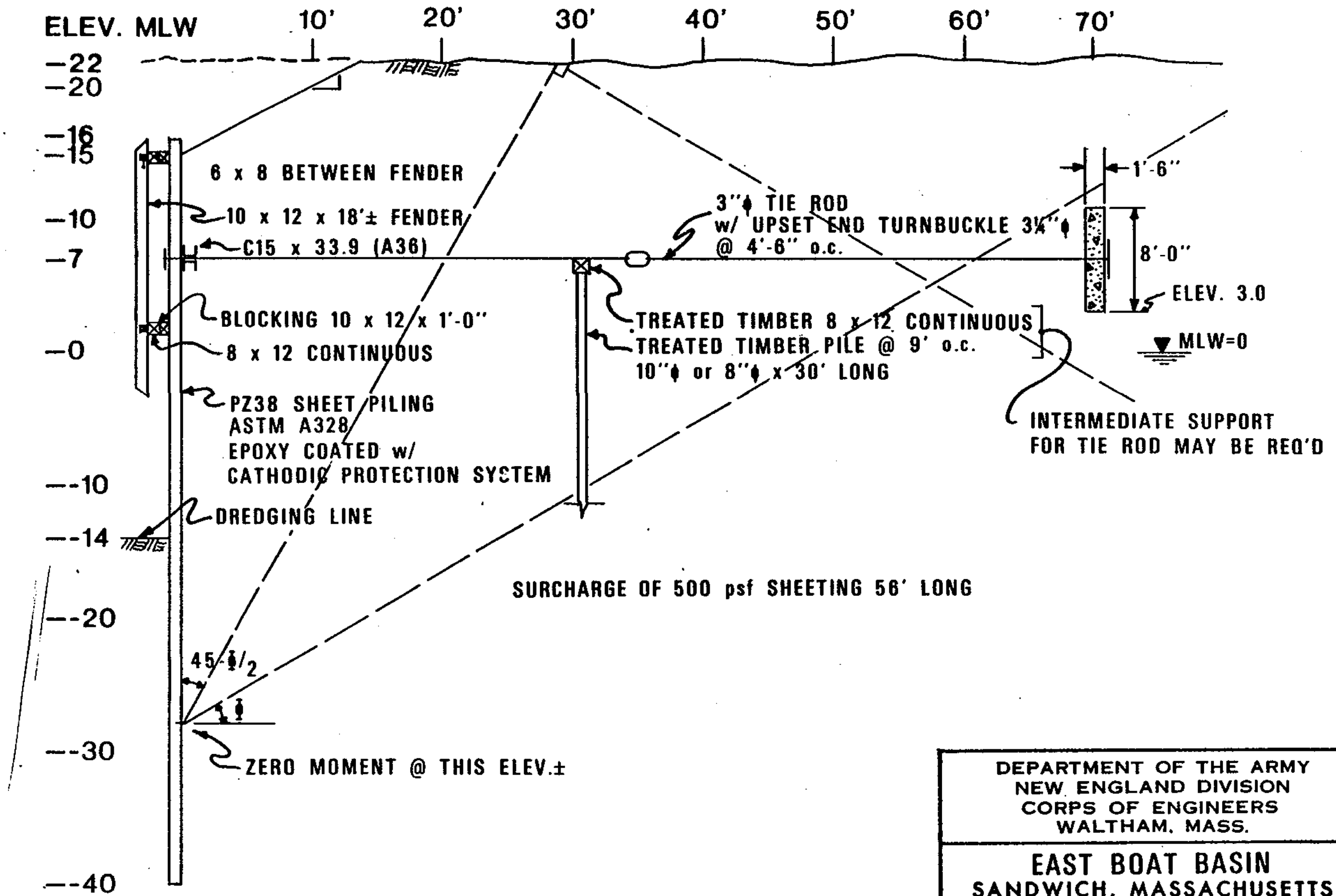
REVETMENT SLOPE SECTION

FIGURE 1-3



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BULKHEAD SECTION

FIGURE 1-4

BOAT STORAGE SYSTEMS

Although the design of boat storage systems is not within the scope of the study, an analysis was performed to provide an approximation of costs that would be incurred from implementation of various systems. These costs are necessary to account for economic costs that affect the determination of economic justification for the project.

A number of methods for wet storage of boats were considered for implementation at the East Boat Basin. There are basically two types of wet storage presently in use, open-mooring with lines and anchors, and berthing in slips. These two systems are discussed below.

Open-Mooring Systems

Open-mooring entails the anchoring of boats in open water by means of a line or lines tied to temporary or semi-permanent anchoring devices located on the harbor bottom. There is a wide variety of mooring schemes available. The most common scheme in use is the single point swing mooring. A single line is attached to the bow from which the boat can swing freely about the anchor. Normally, sufficient swing area is provided to allow the boat to align itself with the wind, wave and current conditions without colliding with other boats. When space is limited, overlap of swing ara is permitted; however, the chance of collision is increased.

Another common practice is to provide more than one anchor, thereby eliminating the need for swing area. Two lines (two-point mooring) or four lines (four-point mooring) attached to the bow and stern are used to prevent the boat's rotational movement. Use of multiple anchors is more efficient than swing mooring systems, in that more boats can be moored in the same area. A major drawback of multi-anchor systems, is the inability of the boat to align itself with the environmental conditions. Broadside orientation to wind, waves and currents causes undesirable forces to be exerted on boats and anchors. Therefore a sheltered area is required for this type of system. Two-point and four-point mooring layouts generally consist of parallel double rows of boats separated by fairways.

The four-point mooring system was selected for analysis, since it is the most efficient mooring system. Expansion space at the East Boat Basin is limited, in addition to the high cost of construction for a landcut. A highly efficient mooring system is required to address these concerns. Also, a multi-anchor system is compatible with the East Boat Basin since it is a well sheltered harbor. The four-point mooring system was analyzed to determine the number of boats that can be moored in a given area, or vice versa, how much area is needed to moor a given number of boats. The resultant formulas derived in the analysis contained at the end of this section were used in the projection of fleet sizes.

Slip Berthing

Berthing of boats in slips is probably the most popular method used for wet storage of boats. It consists of a system of docks and floats connected to the shoreline. Dock systems are generally comprised of interconnected main docks that have smaller finger piers extending out for boats to tie up to. The entire system is anchored to the harbor bottom with piles to prevent lateral movement. The system is permitted to move up and down with the water surface level, which is a requirement at the East Boat Basin because of the large 9 foot tidal range.

Since slip berthing areas require well protected areas for implementation, the East Boat Basin would be an ideal location for its use. Slip berthing is one of the most efficient wet storage methods available, and was therefore analyzed. Boat storage capacity formulas were also developed for use in the projection of fleet sizes when using slip berthing, and are contained after this section.

QUANTITY ESTIMATES

Quantity estimates were developed for the major project components to determine the cost of construction for each plan. Major components of the navigation project include removal of material, placement of riprap revetment and placement of bulkhead. The overall basin development project proposed by the town of Sandwich may require the excavation of up to

500,000 additional cubic yards of material to bring the surrounding area to required grade. However, the surrounding area has no direct relationship with navigation needs, so that quantity estimates were developed for implementation of the navigation project only.

Quantity estimates for material removal were based on the available topographic and hydrographic information. Subsurface investigation indicated no evidence of bedrock, although some boulders and cobbles were encountered. Virtually all of the material is expected to be ordinary material.

Construction Methods

Project costs were estimated based on construction methods judged to be most practical and cost-effective from an engineering point of view. Two construction scenarios, based on consideration of alternative disposal methods, were examined. The first construction method is based on disposal of project material at an open-water/upland combined disposal alternative, and the second is based on open-water disposal alone. In all instances a portion, or all of the project material would be discharged at an open-water disposal site.

The first construction scenario would involve excavation of the landcut in the dry, to an elevation of about 10 feet MLW using land based construction equipment. This elevation is just above the MHW level, thereby permitting continuous dry excavation with minimal tidal interference. The excavated material would be direct loaded into dump trucks for disposal at the selected upland site. During this process, bulkhead would be driven at the necessary locations around the expanded basin perimeter.

Project material to be dredged from within the existing basin, and the remaining landcut material below 10 feet MLW, would be dredged using a bucket or dipper dredge. The dredge would work in from the East Boat Basin and load material directly into scows for disposal at the selected open-water site.

It is estimated that duration of the excavation process would range from about 2.5 months to 4.2 months for the various plans, and the duration of the dredging process would range from about 2.2 months to 2.7 months. The execution of the two phases would not necessarily be sequential, thereby minimizing construction time because of activity overlap. Total material removal duration would probably be somewhat less than the total duration range of 4.7 to 6.7 months. A rough generalized time estimate for material removal duration would be about 6 months.

The second construction scenario would involve dredging all of the project material. A bucket or dipper dredge would work inward from the East Boat Basin and load material directly into scows for disposal at the selected open-water site. A bulldozer would be required to push the landcut material to a lower elevation accessible by the dredge. Bulkhead would be driven at the necessary expanded basin perimeter locations at the appropriate time, which is prior to excavating beyond the top elevation of the bulkhead to maintain soil stability. It is estimated that the duration for material removal under this scenario would range from about 3.2 months to 4.4 months for the various plans.

Material Removal Quantities

The first construction scenario wuld involve both excavation and dredging,and therefore, project material was divided into the two categories. Most of the dredged material would be virgin since it would come from the landcut; however, a small portion of the dredged material would come from the existing basin. Table 1-3 below contains the quantity breakdown of material to be removed for each project component. The breakdown between excavation and dredging is provided for the first construction scenario, with the second construction scenario summarized simply by looking at the total column.

The following abbreviations are used to identify the project features.

EC - Entrance Channel

TM - Turning/manuevering area

CB - Commercial berthing area

RB - Recreational berthing area

OA - Offloading area

Table 1-3

Material Removal Quantities

Plan Feature	Excavation (C.Y.	Dredging (C.Y.) Existing Basin	Landcut	Total (C.Y.)
		Plan A		
EC	11,140	17,140	30,620	58,900
TM	33,930	0	73,550	107,480
CB	50,110	10,820	112,670	173,600
RB	28,080	1,590	35,640	65,310
OA	8,740	0	17,640	26,380
Total	132,000	29,550	270,120	431,670
		Plan B		
EC	8,700	17,140	24,210	50,050
TM	27,720	0	69,660	97,380
CB	121,350	0	182,470	303,820
RB	55,770	1,240	64,650	121,660
OA	7,480	1,530	16,050	25,060
Total	221,020	19,910	357,040	597,970

Plan C

EC	22,390	17,140	48,790	88,320
TM	39,420	0	79,360	118,780
CB	72,210	10,820	139,250	222,280
RB	28,150	1,590	48,090	77,830
OA	9,110	0	18,150	27,260
Total	171,280	29,550	333,640	534,470

Plan D

EC	14,640	13,070	45,160	72,870
TM	16,050	0	34,760	50,810
CB	109,920	0	188,450	298,370
RB	41,880	390	65,450	107,720
OA	8,070	360	20,360	28,790
Total	190,560	13,820	354,180	558,560

Revetment and Bulkhead Quantities

Riprap revetment quantity estimates were based on the length of basin expansion perimeter to be protected by riprap, and the length of protected slope. Riprap quantities were broken out into its two components of gravel bedding and stone protection. Placement of the 15 pound to 240 pound stone protection would occur after construction of the expansion area.

Bulkhead quantities were estimated on a lineal foot basis, and were determined by the length of basin expansion perimeter to be bulkheaded for each alternative. When excavation to the top of bulkhead elevation has been achieved, bulkhead would be driven to the required depth. If cobbles and boulders are encountered in any areas, placement of bulkhead could require excavation and backfilling. Riprap and bulkhead quantities are summarized in Table 1-4. Note that bulkhead is only proposed along the offloading areas, and therefore is shown as a total amount for each plan.

Table 1-4

Revetment and Bulkhead Quantities

Revetment (C.Y.)

Plan Feature	Gravel Bedding	Stone Protection	Bulkhead (L.F.)
		Plan A	
CB	1710	2030	-
RB	1450	1530	-
Total	3160	3560	780
		Plan B	
CB	3440	4080	-
RB	1610	1720	-
Total	5050	5800	1100

Plan C

CB	2150	2520	-
RB	1940	2040	-
Total	4090	4560	780

Plan D

CB	4760	5260	-
RB	1210	1290	-
Total	5970	6550	1050

COST ESTIMATES

Project cost estimates were developed for each of the four alternative plans, based on the engineering investigations, design and quantity estimates contained in the previous section. Unit costs used for cost estimates are October 1983 costs. Total project first costs and annual charges were determined for use in economic analyses.

MATERIAL REMOVAL COSTS

Two methods of material disposal were evaulated for possible implementation, upland disposal and open water disposal. Four upland sites and three open water sites were determined to be potential disposal sites. Unit costs for material removal were developed for various ranges of distance away from the project site, based on the disposal method and the two construction methods previously discussed. Separate unit costs for the excavation and dredging portions of the first construction scenario were determined, whereas the second construction scenario required unit costs for dredging only. Table 1-5 provides the range of unit costs developed for each construction scenario.

Table 1-5

Material Removal Unit Costs*

Disposal Method	Construction Scenario 1 Excavation	Construction Scenario 1 Dredging	Construction Scenario 2 All Dredging
Upland			
5 miles	$3 40		
10 miles	$5.10		
Open-Water			
3 miles		$3.75	$4.00
15 miles		$3.95	$4.25
45 miles		$5.10	$5.40

* Include mob and demob, and 10% profit.

Material removal unit costs, and the estimated durations for the material removal operation, were based on 24 hours a day construction. The dredging unit costs for the two construction scenarios vary somewhat for several reasons. Dredging unit costs of construction scenario 2 include an additional cost for land-based equipment that must assist in the dredging operation. The substantial increase in dredging cost between disposal 15 miles away, and 45 miles away, is due to the need for additional equipment to maintain a desirable production rate and increased disposal distance.

The cost of material removal was determined for fifteen most likely disposal alternatives for each of the four plans, based on the construction scenarios and accompanying unit costs. Costs were determined for each upland site/open-water site combination for the first construction scenario, resulting in twelve disposal alternatives. Each of the three open-water sites above were considered separate disposal alternatives, making a total of 15. Table 1-6 summarizes the disposal alternatives with accompanying distances and unit costs used in determining material removal costs. The following abbreviations were used to designate the disposal locations as deemed viable in Appendix 1, Environmental.

CE - Camp Edwards

CW - Crane Wildlife Management Area

SS - Sagamore site

CG - Corps of Engineers gravel pit

CC - Cape Cod Canal site in Cape Cod Bay

WC - Wellfleet site in Cape Cod Bay

FA - Foul Area

Table 1-6

Disposal Alternative Unit Costs

Disposal Alternative Upland/Open-Water	Distance Away Excavate/Dredge	Unit Cost Excavate/Dredge
D1-CE/CC	6 mi/5.5 mi	$3.30/$3.75
D2-CE/WC	6 mi/16.7 mi	$3.30/$3.95
D3-CE/FA	6 mi/50.0 mi	$3.30/$5.10
D4-CW/CC	15.8 mi/5.5 mi	$5.10/$3.75
D5-CW/WC	15.8 mi/16.7 mi	$5.10/$3.95
D6-CW/FA	15.8 mi/50.0 mi	$5.10/$5.10
D7-SS/CC	2.7 mi/5.5 mi	$3.30/$3.75
D8-SS/WC	2.7 mi/16.7 mi	$3.30/$3.95
D9-SS/FA	2.7 mi/50.0 mi	$3.30/$5.10
D10-CG/CC	4.1 mi/5.5 mi	$3.30/$3.75
D11-CG/WC	4.1 mi/16.7 mi	$3.30/$3.95
D12-CG/FA	4.1 mi/50.0 mi	$3.30/$5.10
D13- /CC	/5.5 mi	/$4.00
D14- /WC	/16.7 mi	/$4.25
D15- /FA	/50.0 mi	/$5.40

The cost of excavating, dredging and disposing of material was estimated by multiplying the unit cost in Table 1-6 by the quantities contained in Table 1-3 of the previous section. The resultant costs are summarized in Table 1-7.

Table 1-7

Material Removal Costs (in 000's)

Disposal Alternative	Plan A	B	C	D
D1	$1,559	$2,143	$1,927	$2,009
D2	$1,619	$2,218	$2,000	$2,082
D3	$1,964	$2,652	$2,417	$2,506
D4	$1,797	$2,541	$2,235	$2,352
D5	$1,857	$2,616	$2,308	$2,425
D6	$2,202	$3,050	$2,726	$2,849
D7	$1,559	$2,143	$1,927	$2,009
D8	$1,619	$2,218	$2,000	$2,082
D9	$1,964	$2,652	$2,417	$2,506
D10	$1,559	$2,143	$1,927	$2,009
D11	$1,619	$2,218	$2,000	$2,082
D12	$1,964	$2,652	$2,417	$2,506
D13	$1,727	$2,392	$2,138	$2,234
D14	$1,835	$2,541	$2,271	$2,374
D15	$2,331	$3,229	$2,886	$3,016

REVETMENT AND BULKHEAD COSTS

Revetment and bulkhead costs were determined by multiplying the quantities of Table 1-4 by the unit costs listed below.

Riprap	
Gravel Bedding	\$12.35/C.Y.
Stone Protection	\$19.45/C.Y.
Bulkhead	\$2900/L.F.

The resultant slope protection costs are summarized in Table 1-8.

Table 1-8

Slope Protection Costs (in 000's)

	Plan			
Slope Protection	A	B	C	D
Riprap revetment				
Gravel bedding	\$39	\$62	\$51	\$74
Stone Protection	\$69	\$113	\$89	\$127
Bulkheading	\$2262	\$3190	\$2262	\$3045

OTHER PROJECT COST

In addition to major cost items, cost estimates were also developed for several other items. They include road relocation, utility relocation, demolition and site work. Table 1-9 presents the lump sum costs for the additional items.

Table 1-9

Other Project Costs (in 000's)

Item	Plan A	Plan B	Plan C	Plan D
Road relocation	$41	$41	$41	$41
Utility relocation	$23	$26	$23	$26
Demolition	$17	$13	$17	$13
Topsoil and seed	$9	$13	$12	$15
Total	$90	$93	$93	$95

SLIP BERTHING COSTS

Cost estimates for providing slips in the expansion area were developed for each plan for the performance of economic analyses. New slips would not be provided in the existing basin since it would be saturated with existing slips under the without-project condition. The existing slips would be reorganized within the existing basin to facilitate the navigation improvement project. Therefore, new slips would only be required in the expansion area.

The present marina consists of a floating dock system anchored with piles; therefore, the same type of system was assumed for the expansion area. Cost estimates were based on multiplying the amount of dock area and number of piles required for each boat, by the number of boats in each plan. Table 1-10 below provides the number of boats projected to be located in the expansion area for each plan.

Table 1-10

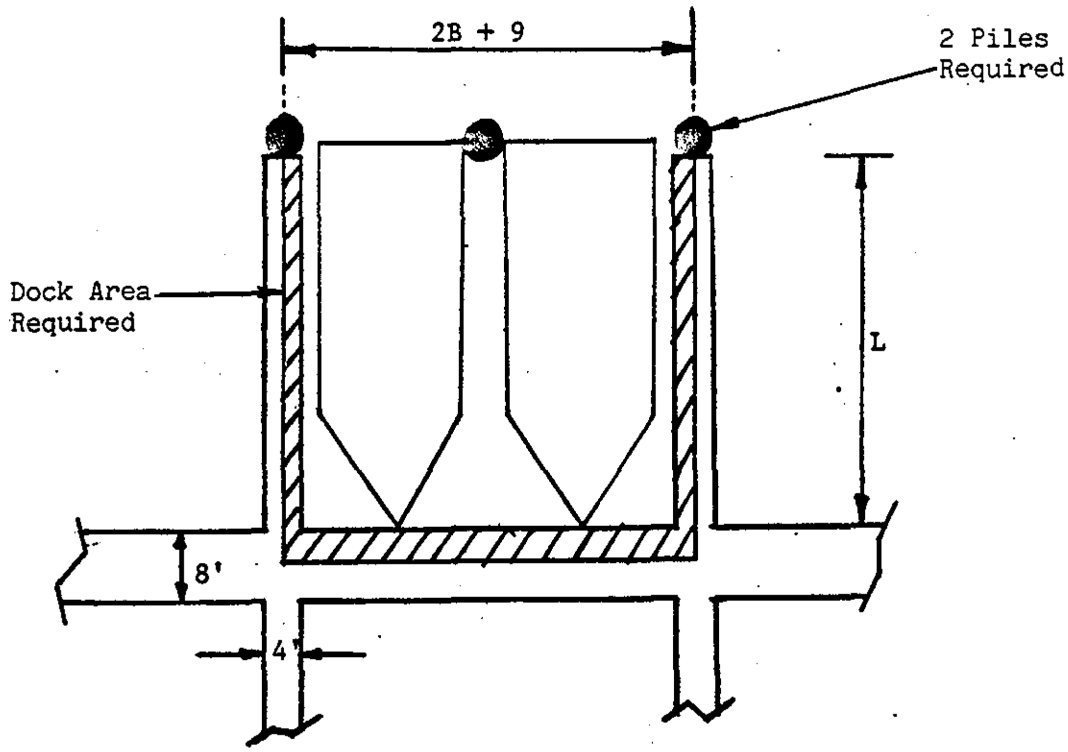
Projected Expansion Area Boats

Plan	Recreational Boats	Commercial Boats
A	41	40
B	72	50
C	55	52
D	90	52*

*Eight of the 52 Plan D commercial boats are existing fleet vessels averaging 42 feet in length.

The amount of dock area and number of piles required were determined from Figure 1-5, which illustrates a typical slip berthing configuration for each type of vessel would be. A 50 percent contingency factor was

RECREATIONAL SLIP



COMMERCIAL SLIP

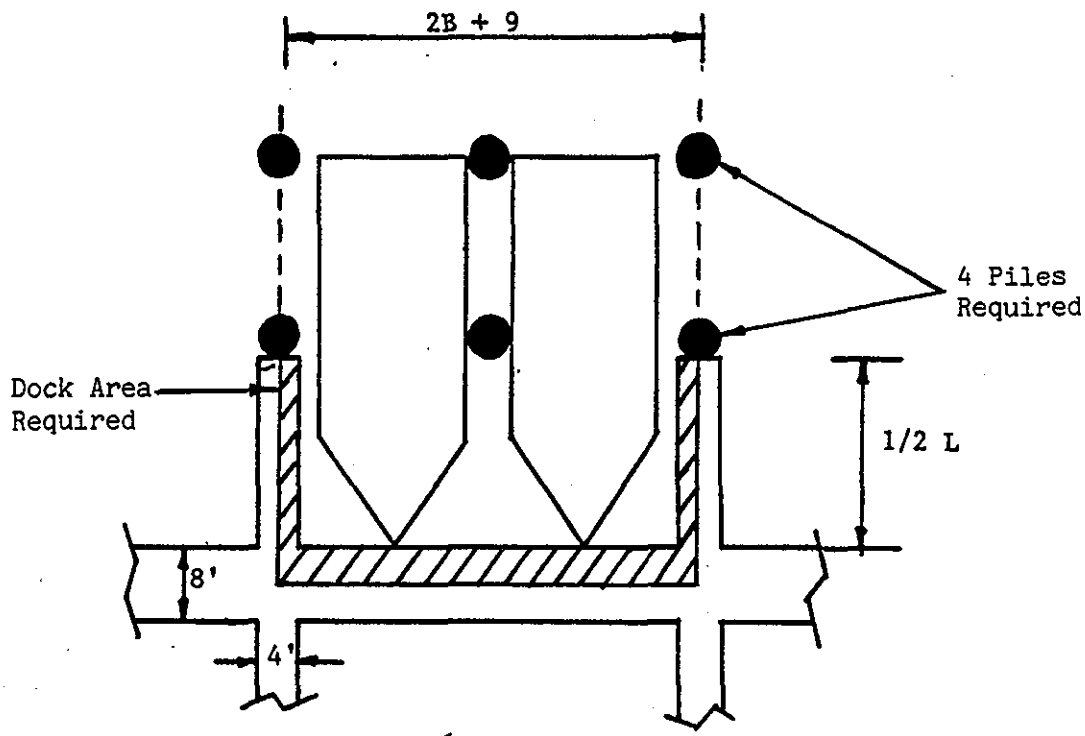


FIGURE 1-5 - SLIP BERTHING CONFIGURATIONS applied to both the resultant dock area and number of piles for each boat, to take into account slip configuration constraints due to basin geometry that could require additional docks and piles. Electrical and water systems were not considered in estimating slip costs, since they are not essential for storage of boats. Cost estimates were developed using construction costs contained in the R.S. Means construction estimating publication. Unit costs include materials, installation, overhead and profit.

Floating Dock Cost Estimates

Dock Area

The dock areas required for each boat were based upon Figure 1-5 and are calculated below, for each size boat. The average vessel sizes used were determined in Section 2, Economics.

Recreational boats: Average size, L = 37', B = 12'

Dock area per boat = $(2B + 9)\ 4 + 2\ (2L) = 8B + 4L + 36\ ft^2$

Dock area per boat = $8\ (12) + 4\ (37) + 36 = 280\ ft^2$

Commercial boats: Average size - New - L = 67', B = 20'

- Existing - L = 42', B = 14'

Dock area per boat = (2B + 9) 4 + 2 (L) = 8B + 2L + 36 ft^2

Dock area per boat (67') = 8 (20) + 2 (67) + 36 = 330 ft^2

Dock area per boat (42') = 8 (14) + 2 (42) + 36 = 232 ft^2

The total amount of dock area was then calculated by multiplying the number of boats times the dock area required per boat and adding the 50 wpercent contingency factor. Total dock areas are summarized below.

Recreational boats: Dock area per boat = 280 ft^2

Plan	Boats	Dock Area (s.f.)	Contingency (s.f.)	Total Area (s.f.)
A	41	11,480	5,740	17,220
B	72	20,160	10,080	30,240
C	55	15,400	7,700	23,100
X	™%	$=R$%%	-$R§%%	+>R]%%

Commercial boats: Dock area per boat (67') = 330 fw$

Dock area per boat (42') = 232 ft^2

Plan	Boats	Dock Area (s.f.)	Contingency (s.f.)	Total Area (s.f.)
A	40	13,200	6,600	19,800
B	50	16,500	8,250	24,750
C	52	17,160	8,580	25,740
D	44	14,520	7,260	21,780
D*	8	1,856	928	2,784

*See note, Table 1-10.

Dock Cost

The cost per square foot of dock area is $17.50 from the Means publication. The total dock area was multiplied by the unit cost to obtain the dock cost for each plan. The dock costs are computed in Table 1-11 below.

Table 1-11

Dock Cost Estimates (in 000's)

	Recreational Boats		Commercial Boats		
Plan	Dock Area(s.f.)	Dock Cost	Dock Area (s.f.)	Dock Cost	Total Cost
A	17,220	$302	19,800	$347	$649
B	30,240	$529	24,750	$434	$963
C	23,100	$404	25,740	$451	$855
D	37,800	$662	24,564	$430	$1,092

Piling Cost Estimates

Piling Analysis

The length of piles placed in the recreational berthing area would differ from the length of piles in the commercial berthing area because of the variation in depth. Pile lengths were assumed to be 44 feet and 52 feet, for the two areas respectively, for purposes of an approximate cost estimate. Piles would be pressure treated for preservation.

Determination of the number of piles necessary for each boat was based on Figure 1-5. One pile per boat would be required for recreational boats, and commercial boats would require 2 piles. The number of boats for each plan were then multiplied by the piles per boat. A 50 percent contingency factor was added to take into account other requirements for piles, yielding the total number of piles for each plan. The total number of piles for each plan are calculated below.

Recreational boats: 1 pile per boat

Plan	Boats	Piles	Contingency	Total Piles
A	41	41	21	62
B	72	72	36	108
C	55	55	28	83
D	90	90	45	35

Commercial boats: 2 piles per boat

Plan	Boats	Piles	Contingency	Total Piles
A	40	80	40	120
B	50	100	50	150
C	52	104	52	156
D	52	104	52	156

Pile Costs

The cost of placing piles depend upon their length, with the cost per lineal foot of pile increasing with length of pile. The recreational boat piles would be \$8.70/ft and commercial boat piles would be \$8.85/ft, resulting in per pile costs of \$382.80 and \$460.20, respectively, when multiplied by the appropriate pile lengths. In addition, a 30 percent factor for a barge mounted driving rig was added, resulting in total cost per pile of \$497,64 and \$598.26.

Using the previous cost per pile, the total pile placement cost for each plan was computed. The results are contained in Table 1-12, and include a .81 per lineal foot cost for mobilization.

Table 1-12

Piling Cost Estimates (in 000's)

Plan	Recreational Piles	Recreational Cost	Recreational Mob*	Recreational Total	Commercial Piles	Commercial Cost	Commercial Mob*	Commercial Total
A	62	$31	$2	$32	120	$72	$5	$77
B	108	$54	$4	$58	150	$90	$6	$96
C	83	$41	$3	$44	156	$93	$7	$100
D	135	$67	$5	$72	156	$93	$7	$100

*Mobilization was determined by multiplying the number of recreational piles by 44 feet, and the number of commercial piles by 52 feet, and then applying the $.81 per lineal foot mobilization factor to each class.

Total Slip Berthing Costs

The total slip berthing cost was determined by summing the dock cost estimates and piling cost estimates, performed in Table 1-13 below.

Table 1-13

Total Slip Berthing Costs (in 000's)

	Recreational			Commercial			Total
Plan	Dock	Piles	Total	Dock	Piles	Total	Cost
A	$302	$32	$334	$347	$77	$424	$758
B	$529	$58	$587	$434	$96	$530	$1,117
C	$404	$44	$448	$451	$100	$551	$999
D	$662	$72	$734	$430	$100	$530	$1,264

BASIN ENTRANCE COSTS

Two possible future conditions exist for the east side of the basin entrance depending upon the action taken by the Corps of Engineers and the timing of projects. Conditions may remain as they are, or the present bulkhead may be replaced with a riprap slope. Therefore, both possible conditions were considered. Any costs required to modify the basin entrance due to the proposed project would be part of the total entrance channel cost. However, the costs determined in the following sections include only work east of the proposed channel line for comparison, of the two basin entrance alternatives. Costs for removal of channel material west of the channel line are included as part of the entrance channel material removal cost.

Basin Entrance - Existing Conditions

Construction of the proposed 180 foot wide entrance channel would bring the east channel line even with the existing bulkhead return that is tied into the present riprap slope. The bulkhead would then be extended sufficiently to maintain the necessary channel width, without disrupting existing activities. The bulkhead would effectively become the channel line. Construction of the modifications would include placement of about 95 lineal feet of bulkhead, and the removal of about 1075 cubic yards of material east of the channel line. Material removal would be considered dredged material, and would therefore be disposed at the selected open-water site. Unit costs for material removal, previously developed, were used to determine the cost of basin entrance modification. The cost of placing bulkhead would be the same, $276,000 for all plans. Table 1-14 summarizes the total cost of basin entrance modifications for the various disposal alternatives.

Table 1-14

Basin Entrance Costs (in 000's) - Existing Conditions

Disposal Alternative	Material Removal Cost	Basin Entrance Cost
D-1,4,7,10	$4	$280
D-2,5,8,11	$4	$280
D-3,6,9,12	$5	$281
D-13	$4	$280
D-14	$5	$281
D-15	$6	$282

Basin Entrance - Bulkhead Replacement Plan

With construction of the proposed Corps of Engineers bulkhead replacement plan, as shown on Figure 10 of the Feasibility Report, the existing bulkhead and associated activities would be removed. Under this plan, the bulkhead would be replaced with a riprap slope joined to the existing riprap slope extending from within the basin. In order to provide the necessary channel width, the existing riprap slope would have to be moved eastward. This basin entrance modification would entail removal of about 5020 cubic yards of material, and placement of about 670 cubic yards of revetment materials on the new slope. The cost of placing the revetment would be the same for all plans, $11,000, based on gravel fill and stone protection quantities of 270 cubic yards and 400 cubic yards, respectively and unit costs previously developed. The cost of material removal would vary slightly based on the disposal alternative. Total basin entrance costs under theis scenario are summarized in Table 1-15.

Table 1-15

Basin Entrance Costs (in 000's) - Bulkhead Replacement Plan

Disposal Alternative	Material Removal Cost	Basin Entrance Cost
D-1,4,7,10	$19	$30
D-2,5,8,11	$20	$31
D-3,6,9,12	$26	$37
D-13	$20	$31
D-14	$21	$32
D-15	$27	$38

TOTAL PROJECT FIRST COSTS

This section summarizes the total project first cost of alternative plans for each disposal alternative. The total project cost includes all costs estimated in the previous sections that are applicable to each alternative plan. The cost of modifying the existing basin entrance was included rather than the cost of modifying the basin entrance under the bulkhead replacement plan, since the future status of the latter condition is less certain. Also, the estimated cost of this basin entrance condition is greater, resulting in a more conservative project cost estimate. The project total first cost summaries contained in Table 1-16, represent anticipated financial outlays for construction of the navigation project.

Table 1-16

Total Project First Cost (in 000's)

Disposal Alternative - D1, D7, D10

Item	Plan A	Plan B	Plan C	Plan D
Material	$1,559	$2,143	$1,927	$2,009
Riprap Revetment	108	175	140	201
Bulkhead	2,262	3,190	2,262	3,045
Basin Entrance	280	280	280	280
Other Costs	90	93	93	95
Subtotal	$4,299	$5,881	$4,702	$5,630
20% Contingency	860	$1,176	940	1,126
Subtotal	$5,159	$7,057	$5,642	$6,756
7% E & D	361	494	395	473
7% S & A	361	494	395	473
Total	$5,881	$8,045	$6,432	$7,702

Disposal Alternative - D2, D8, D11

Item	Plan A	Plan B	Plan C	Plan D
Material	$1,619	$2,218	$2,000	$2,082
Riprap Revetment	108	175	140	201
Bulkhead	2,262	3,190	2,262	3,045
Basin Entrance	280	280	280	280
Other Costs	90	93	93	95
Subtotal	$4,359	$5,956	$4,775	$5,703
20% Contingency	872	1,191	955	1,141
Subtotal	$5,231	$7,147	$5,730	$6,844
7% E & D	366	500	401	479
7% S & A	366	500	401	479
Total	$5,963	$8,147	$6,532	$7,802

Disposal Alternative - D3, D9, D12

Item	Plan A	Plan B	Plan C	Plan D
Material	$1,964	$2,652	$2,417	$2,506
Riprap Revetment	108	175	140	201
Bulkhead	2,262	3,190	2,262	3,045
Basin Entrance	281	281	281	281
Other Costs	90	93	93	95
Subtotal	$4,705	$6,391	$5,193	$6,128
20% Contingency	941	1,278	1,039	1,226
Subtotal	$5,646	$7,669	$6,232	$7,354
7% E & D	395	537	436	515
7% S & A	395	537	436	515
Total	$6,436	$8,743	$7,104	$8,384

Disposal Alternative - D4

Item	Plan A	Plan B	Plan C	Plan D
Material	$1,797	$2541	$2,235	$2,352
Riprap Revetment	108	175	140	201
Bulkhead	2,262	3,190	2,262	3,045
Basin Entrance	280	280	280	280
Other Costs	90	93	93	95
Subtotal	$4,537	$6,279	$5,010	$5,973
20% Contingency	907	1,256	1,002	1,195
Subtotal	$5,444	$7,535	$6,012	$7,168
7% E & D	381	527	421	502
7% S & A	381	527	421	502
Total	$6,206	$8,589	$6,854	$8,172

Disposal Alternative - D5

Item	Plan A	Plan B	Plan C	Plan D
Material	$1,857	$2,616	$2,308	$2,425
Riprap Revetment	108	175	140	201
Bulkhead	2,262	3,190	2,262	3,045
Basin Entrance	280	280	280	280
Other Costs	90	93	93	93
Subtotal	$4,597	$6,354	$5,083	$6,044
20% Contingency	919	1,271	1,017	1,209
Subtotal	$5,516	$7,625	$6,100	7,253
7% E & D	386	534	427	508
7% S & A	386	534	427	508
Total	$6,288	$8,693	$6,954	$8,269

Disposal Alternative - D6

Item	Plan A	Plan B	Plan C	Plan D
Material	$2,202	$3,050	$2,726	$2,849
Riprap Revetment	108	175	140	201
Bulkhead	2,262	3,190	2,262	3,045
Basin Entrance	281	281	281	281
Other Costs	90	93	93	95
Subtotal	$4,943	$6,789	$5,502	$6,471
20% Contingency	989	1,358	1,100	1,294
Subtotal	$5,932	$8,147	$6,602	$7,765
7% E & D	415	570	462	544
7% S & A	415	570	462	544
Total	$6,762	$9,287	$7,526	$8,853

Disposal Alternative - D13

Item	Plan A	Plan B	Plan C	Plan D
Material	$1,727	$2,392	$2,138	$2,234
Riprap Revetment	108	175	140	201
Bulkhead	2,262	3,190	2,262	3,045
Basin Entrance	280	280	280	280
Other Costs	90	93	93	95
Subtotal	$4,467	$6,130	$4,913	$5,855
20% Contingency	893	1,226	983	1,171
Subtotal	$5,360	$7,356	$5,896	$7,026
7% E & D	375	515	413	492
7% S & A	375	515	413	492
Total	$6,110	$8,386	$6,722	$8,010

Disposal Alternative - D14

Item	Plan A	Plan B	Plan C	Plan D
Material	$,1835	$2,541	$2,271	$2,374
Riprap Revetment	108	175	140	201
Bulkhead	2,262	3,190	2,262	3,045
Basin Entrance	281	281	281	281
Other Costs	90	93	93	95
Subtotal	$4,576	$6,280	$5,047	$5,996
20% Contingency	915	1,256	1,009	1,199
Subtotal	$5,491	$7,536	$6,056	$7,195
7% E & D	384	528	424	504
7% S & A	384	528	424	504
Total	$6,259	$8,592	$6,904	$8,203

Disposal Alternative - D15

Item	A	B	C	D
	Plan			
Material	$2,331	$3,229	$2,886	$3,016
Riprap Revetment	108	175	140	201
Bulkhead	2,262	3,190	2,262	3,045
Basin Entrance	282	282	282	282
Other Costs	90	93	93	95
Subtotal	$5,073	$6,969	$5,663	$6,639
20% Contingency	1,015	1,394	1,133	1,328
Subtotal	$6,088	$8,363	$6,796	$7,967
7% E & D	426	585	476	558
7% S & A	426	585	476	558
Total	$6,940	$9,533	$7,748	$9,083

The slip costs roughly estimated in the previous section are not considered attributable to the navigation project, but rather are considered as associated costs necessary to achieve the project benefits. The following Table 1-17 summarizes berthing costs including contingencies, enginering and design, and supervision and administration.

Table 1-17

Slip Costs (000's

Item	Plan A	Plan B	Plan C	Plan D
Recreational berthing	$334	$587	$448	$734
20% Contingency	67	117	90	147
Subtotal	$400	$704	$538	$881
7% E & D	28	49	38	62
7% S & A	28	49	38	62
Subtotal	$456	$802	$614	$1,005
Commercial berthing	$424	$530	$551	$530
20% Contingency	85	106	110	106
Subtotal	$509	$636	$661	$636
7% E & D	36	45	46	45
7% S & A	36	45	46	45
Subtotal	$581	$726	$753	$726
Total	$1,037	$1,528	$1,367	$1,731

ANNUAL COSTS

Average Annual Costs

The average annual cost for each plan was determined by amortizing the total navigation project first cost over a 50-year project life. The discount rate applicable to Federal projects is .0829, which corresponds to a 8.125 percent annual interest rate. The average annual cost was determined for all plans for each disposal alternative, and is summarized in Table 1-18.

Table 1-18

Average Annual Cost (in 000's)

Disposal Alternative	Plan A	B	C	D
D1,D7,D10	$488	$667	$533	$638
D2,D8,D11	$494	$675	$542	$647
D3,D9,D12	$534	$725	$589	$695
D4	$514	$712	$568	$677
D5	$521	$721	$576	$686
D6	$561	$770	$624	$734
D13	$507	$695	$557	$664
D14	$519	$712	$572	$680
D15	$575	$790	$642	$753

Annual Maintenance Costs

There has been no maintenance dredging performed in the East Boat Basin since it was last expanded in 1963. No material enters the basin from the Cape Cod Canal, since the fast moving canal current prevents transportation of suspended material into the East Boat Basin. The lack of streamflow into the basin precludes deposition of material from streams. Basin slopes are presently protected or would be protected by riprap revetment or bulkhead, thereby restricting erosion of surrounding areas into the basin. The harbormaster has indicated that some shoaling has taken place along the riprap slopes. The shoaling is not extensive, and could be due to slope material making its way into the basin or the movement of suspended materials from other parts of the basin over a period of time. The major cause of material movement within the basin is from boat propwash and tidal currents near the basin entrance. The same conditions are expected to prevail in an expansion project, and therefore the need to maintenance dredge was assumed to be minimal.

Upon project completion, shoaling is anticipated to occur primarily in the deeper portions of the expansion project, such as the entrance channel and turning/maneuvering areas. Bottom material would slump or be moved from the higher berthing areas to lower portions of the project due to vessel propwash and currents. Once the displacement process has stabilized, and with minimal outside material entering the basin, maintenance dredging is not expected to occur very often. However, for purposes of economic evaluation an annual maintenance dredging charge was determined.

A somewhat arbitrary procedure was followed to determine the annual maintenance dredging charge. It is based on taking a 4 percent shoal rate, which is representative of shoaling rates in typical harbors, and applying it against the initial dredge volume to obtain the annual shoaling amount. The steps used are delineated below.

1. The basin expansion was assumed to be in place without the entrance channel, turning/maneuvering area and offloading area being at their proposed depths.

2. The initial dredging volume was assumed to consist of material from construction of the entrance channel, turning/maneuvering area and offloading area.

3. The initial dredging volume was determined by multiplying the total surface area of areas listed in step 2, by the average difference in elevation between berthing areas and those areas.

4. The initial dredge volume was multiplied by the 4 percent shoal rate to obtain the annual maintenance dredging quantity.

5. Resultant annual maintenance dredging amounts for each plan were multiplied by a $10 per cubic yard unit cost, to obtain the annual maintenance dredging charge.

The annual maintenance dredging charge for each plan has been determined in Table 1-19 below.

Table 1-19

Annual Maintenance Dredging Charge

Plan	Shoaling Area (ft^2)	Dredged Quantity (yd^3)	Annual Maintenance Quantity (yd^3)	Annual Maintenance Charge
A	239,000	35,000	1,400	$14,000
B	240,000	36,000	1,440	$14,000
C	257,000	38,000	1,520	$15,000
D	216,000	32,000	1,280	$13,000

Notes:

1. Average elevation difference used was 4 feet.
2. Shoaling rate was 4 percent.
3. Unit cost is $10/yd^3.

In addition to maintenance dredging, an annual charge for maintenance of riprap was established. Since the basin is a well protected area, damage to riprap slopes due to large waves was assumed to be minimal. This assumption is borne out by the minimal riprap maintenance performed over the years. Therefore, a nominal annual charge of $2000 for riprap maintenance was assumed for each plan.

The U.S. Coast Guard is responsible for placing navigation aids in Federal channels and maintaining them. Some buoys would be placed in the East Boat Basin to delineate the channel; however, they may not be necessary since harbor areas would be well defined. A nominal annual charge of $1000 was assumed for maintenance of aids to navigation.

Total annual maintenance charges are summarized in Table 1-20 below.

Table 1-20

Total Annual Maintenance Charge

Plan	Dredging	Riprap	Aids to Navigation	Total
A	$14,000	$2,000	$1,000	$17,000
B	$14,000	$2,000	$1,000	$17,000
C	$15,000	$2,000	$1,000	$18,000
D	$13,000	$2,000	$1,000	$16,000

Total Annual Costs

Total annual costs, including amortization costs and maintenance charges, are summarized in Table 1-21 for all plans for each disposal alternative.

Table 1-21

Total Annual Costs (in 000's)

Disposal Alternative	Plan A	B	C	C
D1,D7,D10	$505	$684	$551	$654
D2,D8,D11	$511	$692	$560	$663
D3,D9,D12	$551	$742	$607	$771
D4	$531	$729	$586	$693
D5	$538	$738	$594	$702
D6	$578	$787	$642	$750
D13	$524	$172	$575	$680
D14	$536	$729	$590	$696
D15	$592	$807	$660	$769

SLOPE STABILITY INVESTIGATION

SLOPE STABILITY INVESTIGATION, EAST BOAT BASIN

CAPE COD CANAL, SANDWICH, MA

GEOTECHNICAL ENGINEERING BRANCH

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Waltham, Massachusetts 02254

December 1981

SUMMARY

The slope stability investigation for the proposed East Boat Basin Expansion, Cape Cod Canal, Sandwich, MA concludes that cut slopes of 1 (vertical) on 2 (horizontal) will be stable against shear failure. Additional subsurface explorations will be required during final design to define foundation conditions in more detail and to confirm the assumptions made in this investigation.

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1. INTRODUCTION. This report has been prepared to present the results of the earth cut slope stability investigation (Stage III planning level) for the proposed expansion of East Boat Basin.

2. DESCRIPTION OF SITE

a. General. The proposed East Boat Basin expansion site is located on the south side of the Cape Cod Canal, approximately two miles east of the Sagamore Bridge. The East Boat Basin was constructed in the 1930s to provide an anchorage area for construction vessels working on the canal widening project. In 1963 the basin was expanded to its present size.

b. Topography. The results of topographic and hydrographic survey completed in 1978 and 1979 are shown on Plate 1. The ground is generally flat at approximately elevation 24 feet (MLW) sloping gradually down to the existing basin in a northerly direction. The proposed expansion site is surrounded by Gallo Road to the east, Penn Central Railroad tracks to the south, a service road to the west and the existing basin to the north.

c. Surface Drainage. The proposed site presently drains to the existing basin to the north and partially to a drainage ditch in the southwestern corner of the site. The drainage ditch is approximately 10 feet deep with a bottom elevation of approximately + 12 feet (MLW) and connects to a culvert which crosses under the Penn Central Railroad tracks. Older topographic maps indicate that the drainage ditch previously drained to the existing basin from marsh areas south of the railroad tracks. The proposed expansion site is a fill area and the previous drainage pattern has been diverted.

d. Flood Conditions. Mean high water is elevation 8.67 feet (MLW) with an extreme high water elevation of 13.97 feet (MLW). Wave heights are considered to be minimal (less than 2 feet) as the basin is protected from open waters.

3. EVALUATION

a. Subsurface Investigations. A preliminary exploration program of five drive sample borings were completed in July 1981 for the purpose of defining subsurface conditions and to develop a typical soil profile. The boring information was also utilized in developing soil parameters for use in a stability analysis for the proposed excavated basin slope. Exploration logs and results of laboratory tests for the proposed East Boat Basin expansion site are in

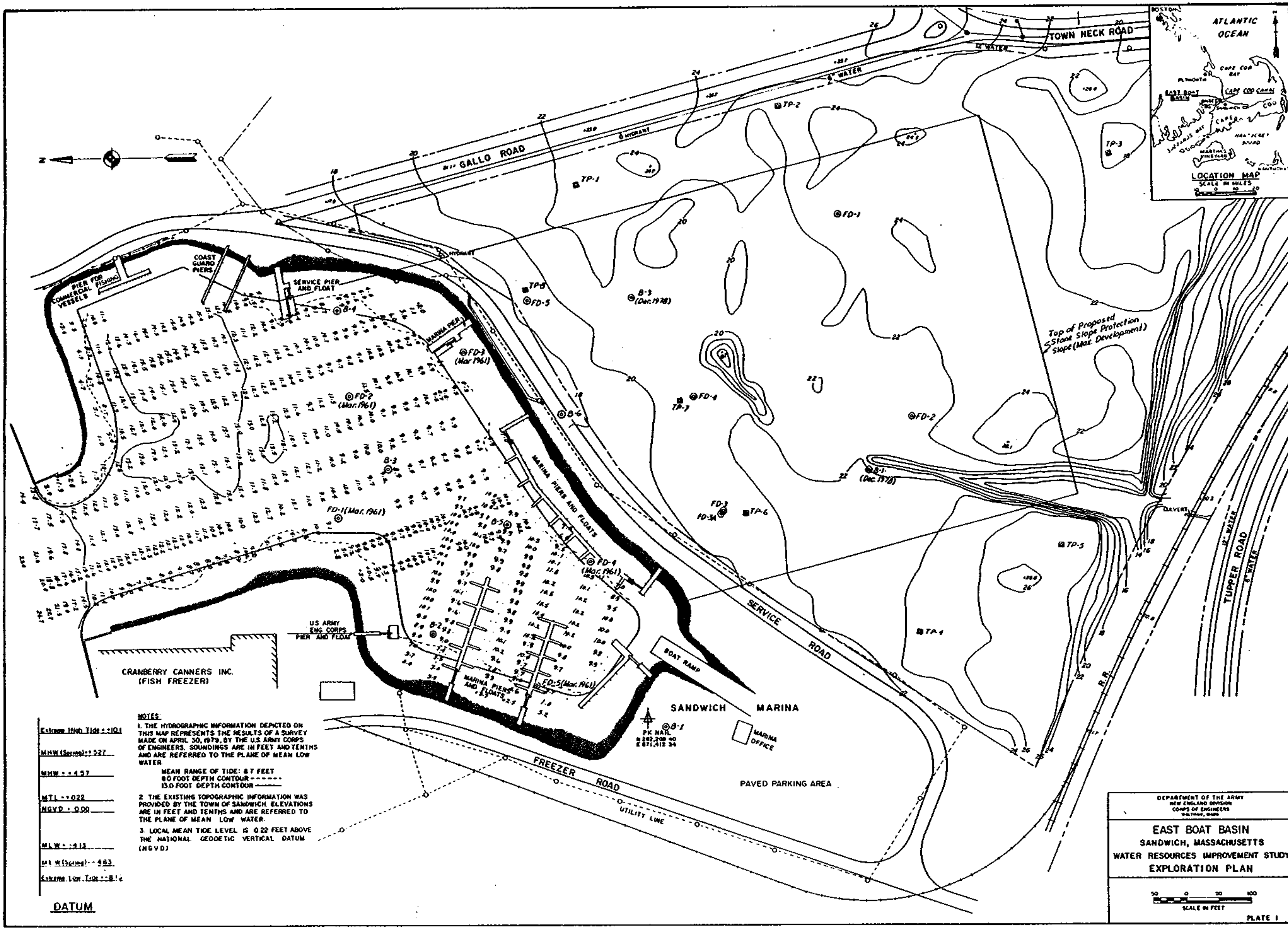
Appendix A and B of this report. Other available subsurface information utilized in determining soil parameters are included in reports listed in the bibliography, Appendix D.

The exploration program as originally proposed was to consist of five standard penetration explorations to a depth of 50 feet. Undisturbed samples were to be taken when fine grained soils (clays-silts) were encountered. Due to the stiffness of the fine grained soils encountered and presence of gravel and small cobbles only disturbed samples could be obtained.

b. Subsurface Conditions. Results of the preliminary subsurface investigation program, review of available subsurface information and site reconnaissance indicate that the proposed East Boat Basin expansion site has a heterogeneous soil stratigraphy of cohesive and non-cohesive soils. Within the soil profile there is a wide variation in soil type and strata thickness. Boulders and cobbles were encountered in several locations with two explorations being terminated 30 feet short of the proposed 50 foot exploration depth due to hitting boulders and cobbles. The soil profile at the proposed East Boat Basin site consists of 10 to 15 feet of fill material consisting mostly of loose silty sands with occasional pockets of clayey silt and peat containing roots and pieces of wood. Below the fill material is a 5 to 10 foot layer of silty sand followed by a transition to stiff to hard clayey silt 15 to 20 feet in thickness. Underlying the clayey silt is a dense strata of silty and gravelly sand to at least a depth of 50 feet where three of the July 1981 explorations were terminated.

c. Tidal Range and Groundwater. The normal range of the tide at the East Boat Basin is 8.7 feet, with mean low water (MLW) at 4.13 feet below NGVD. The mean spring range of tide is 10.1 feet. Historically, an extreme high tide of 14.2 feet above MLW was experienced during the storm of 7 February 1978, and the National Ocean Survey (NOS) estimates the extreme low tide, (date unknown), to have been 4.0 feet below MLW. Tidal datum plane information is given on plate 1. The groundwater elevation within the proposed expansian site fluctuates with the tide and is indicated on the boring logs in Appendix A. Groundwater readings were recorded between elevation 6.4 feet (MLW) in boring FD-5 and elevation 14.2 feet (MLW) in boring FD-4.

d. Soil Parameters. For the purpose of analysis a typical soil profile was developed (see Plates 2 and 3) utilizing all available geotechnical information. The typical soil profile consists of a 26 foot upper strata of fill material and loose silty sand overlying a 16 foot strata of stiff to hard clayey silt which all overlies a firm base of dense silty and gravelly sand. The soil parameters used for the stability analysis of the proposed excavated slope were derived by correlating all available information. Review and correlation was made of blow count information, Atterberg limits, grain size analysis and standard tables. Vane shear and penetrometer test results available in the Stone & Webster Subsurface Investigation Canal Plant - Unit 2 Report, 1972 were also utilized as they pertained to the typical clayey silt strata as indicated on the typical soil profiles (plates 2 and 3). The Canal Plant - Unit 2 site is approximately 2500 feet west of the proposed East Boat Basin site.



ATLANTIC OCEAN
BOSTON
PLYMOUTH
CAPE COD BAY
EAST BOAT BASIN
CAPE COD CANAL
SANDWICH
BUZZARDS BAY
NANTUCKET SOUND
MARTHAS VINEYARD
LOCATION MAP
SCALE IN MILES
TOWN NECK ROAD
12" WATER
8" WATER
GALLO ROAD
HYDRANT
TP-1
TP-2
TP-3
TP-4
TP-5
TP-6
TP-7
TP-8
FD-1
FD-2
FD-3
FD-3A
FD-4
FD-5
B-1 (Dec. 1978)
B-3 (Dec. 1978)
Top of Proposed Stone Slope Protection Slope (Max. Development)
CULVERT
TUPPER ROAD
12" WATER
8" WATER
R.R.
PIER FOR COMMERCIAL FISHING VESSELS
COAST GUARD PIERS
SERVICE PIER AND FLOAT
MARINA PIER
FD-3 (Mar. 1961)
FD-2 (Mar. 1961)
FD-1 (Mar. 1961)
FD-4 (Mar. 1961)
FD-5 (Mar. 1961)
B-4
B-3
B-5
B-6
B-2
B-1
MARINA PIERS AND FLOATS
SERVICE ROAD
BOAT RAMP
US ARMY ENG CORPS PIER AND FLOAT
CRANBERRY CANNERS INC. (FISH FREEZER)
SANDWICH MARINA
PK NAIL
MARINA OFFICE
PAVED PARKING AREA
FREEZER ROAD
UTILITY LINE
Extreme High Tide = +10.1
MHW (Spring) = +5.27
MHW = +4.57
MTL = +0.22
NGVD = 0.00
MLW = -4.13
MLW (Spring) = -4.83
Extreme Low Tide = -8.1
DATUM
NOTES:
1. THE HYDROGRAPHIC INFORMATION DEPICTED ON THIS MAP REPRESENTS THE RESULTS OF A SURVEY MADE ON APRIL 30, 1979, BY THE U.S. ARMY CORPS OF ENGINEERS. SOUNDINGS ARE IN FEET AND TENTHS AND ARE REFERRED TO THE PLANE OF MEAN LOW WATER.
MEAN RANGE OF TIDE: 8.7 FEET
8.0 FOOT DEPTH CONTOUR
13.0 FOOT DEPTH CONTOUR
2. THE EXISTING TOPOGRAPHIC INFORMATION WAS PROVIDED BY THE TOWN OF SANDWICH. ELEVATIONS ARE IN FEET AND TENTHS AND ARE REFERRED TO THE PLANE OF MEAN LOW WATER.
3. LOCAL MEAN TIDE LEVEL IS 0.22 FEET ABOVE THE NATIONAL GEODETIC VERTICAL DATUM (NGVD)
DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.
EAST BOAT BASIN
SANDWICH, MASSACHUSETTS
WATER RESOURCES IMPROVEMENT STUDY
EXPLORATION PLAN
50 0 50 100
SCALE IN FEET
PLATE 1

e. Stability Analysis. Initially simplified procedures for preliminary determination of slope stability were utilized to narrow down the more critical conditions including tidal levels, range of slopes and slope stability analysis cases. After the more critical conditions were narrowed down, a computer program was used to further analyze the proposed slope. The title of the computer program which was prepared by WES, Vicksburg, MS is Slope Stability Analysis, Modified Swedish Method - I009.

Numerous computer runs were made varying tidal levels, failure surfaces and soil parameters to identify the most critical conditions. One analysis was checked by hand calculation and graphic analysis to verify the validity of the computer program. The two most critical cases are shown on plates 2 and 3. The lowest calculated factors of safety are 1.35 for the sudden drawdown case and 1.36 for the end of construction case for a slope of 1 (vertical) on 2 (horizontal). In both cases the failure arcs pass through the interface between the stiff clayey silt and dense silty sand at approximately elevation -18 feet (MLW) and intersect the cut slope near the toe.

4. CONCLUSIONS

It is concluded that cut slopes of 1 (vertical) on 2 (horizontal) or flatter, for proposed basin expansion will be stable against shear failure. The basin should be designed with 1 (vertical) on 2 (horizontal) cut slopes provided with stone slope protection and gravel bedding. During final design additional subsurface explorations will be required to define foundation conditions in more detail and to confirm the assumptions used in this investigation.

APPENDIX A

EXPLORATION LOGS

DATE OF EXPLORATION 13-23 JULY 1981

U. S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

FIELD LOG OF TEST BORING

Site East Boat Basin Page 1 of 7 Pages
Boring No. FD-1 Desig. 4 Diam. (Casing) 4 in. HW
Co-ordinates: N ______ E ______

Elevation Top of Boring ≈ 19.6 Ft M.S.L. Hammer Wt. 140 lb Boring Started 7-17-81
Total Overburden Drilled 50.0 Feet Hammer Drop 30 in. Boring Completed 7-21-81
Elevation Top of Rock None Encountered M.S.L. Casing Left None
Total Rock Drilled None Feet Subsurface Water Data ______ Page ______
Elevation Bottom of Boring -30.4 Ft M.S.L. Obs. Well None
Total Depth of Boring 50.0 Feet Drilled By Briggs Engineering + Testing Co.
Core Recovered N/A % No. Boxes ______ Mfg. Des. Drill Acker
Core Recovered N/A Ft : ______ Diam. ______ in. Inspected By: Ronald F. Bukowski
Soil Samples 1 3/8 in. Diam. 12 No. Classification By: ______
Soil Samples 3 & 4 in. Diam. 2 No. Classification By: ______

DEPTH: Blows on Casing	DEPTH: Ft	CORE/SAMPLE: NO.	SIZE	DEPTH RANGE	BLOWS PER FT. / CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
21		S-1, 1 JAR	1 3/8"	0.0 to 0.5'	12	DROVE 1 3/8 x 24" SPLIT-SPOON SAMPLER FROM 0.0 TO 2.0'	SURFACE: TALL GRASS - BRUSH TO 10' HIGH, FEW COBBLES TO 1.0' VISIBLE ON SURFACE.
22	1	S-2, 1 JAR	1 3/8"	0.5 to 2.0'	19, 14	RECOVERED 24"	TOPSOIL: SILTY SAND, COARSE TO FINE SAND, 30-35% NON-PLASTIC FINES, 25-30% ORGANIC MATERIAL SUCH AS LEAVES, ROOTS, GRASS AND WOOD CHIPS DAMP, DARK BROWN TO BROWN, SM.
	2				18	DROVE 4" CASING FROM 0.0 TO 5.0'. REMOVED CASING AND HOLE REMAINED OPEN. SAMPLE TAKEN FROM TIP OF CASING WHEN REMOVED. (S-3).	SILTY SAND, COARSE TO FINE SAND, PREDOMINATELY FINE SAND, 30-40% SLIGHTLY PLASTIC FINES, < 10% FINE GRAVEL, MOIST, BROWN MOTTLED GRAY, SM.
14	3						
15	4						
16	5	S-3, 1 JAR	4"	4.5 to 5.0'			INTERBEDDED SILT, SAND AND PEAT. CLAYEY SILT, LOW PLASTICITY MOIST GRAY. SAND, MEDIUM TO FINE, < 5% GRAVEL, MOIST, BROWN. PEAT, DECAYING WOOD, AND ROOTS, SLIGHT ORGANIC ODOR.

GENERAL REMARKS: BORING DEPTHS ARE REFERENCED TO EXISTING SURFACE, BLOWS ON CASING FROM 300 lb HAMMER UNLESS OTHERWISE NOTED, DROPPED FROM 18 in.

Site: EAST BOAT BASIN SANDWICH, MA	Boring No. FD-1	Page 2 of 7

Blows on Casing	Depth 1" = 1'	Core/Sample No.	Size	Depth Range	Blows per ft. / Core Recvy	Sampling and Coring Operations	Classification of Materials
10		S-4 1 JAR	$1\frac{3}{8}$"	5.0 TO 5.5	2	DROVE $1\frac{3}{8}$ x 24" SPLIT-SPOON SAMPLER FROM 5.0 TO 6.5'	CLAYEY SILT, LOW PLASTICITY < 5% FINE GRAVEL INTERSPERSED, MOIST GRAY MOTTLED RUSTY BROWN, ML.
	6	S-5 1 JAR	$1\frac{3}{8}$"	5.5 TO 6.5'	5, 6	RECOVERED 18" DROVE CASING FROM 5.0 TO 6.5'. PULLED CASING AND HOLE REMAINED OPEN.	INTERBEDDED PEAT, CLAYEY SILT, + SAND, THIN SEAMS OF MEDIUM TO FINE SAND, LOW PLASTICITY ORGANIC SILT AND POCKETS OF CLAYEY SILT, MOIST, BROWN TO DARK BROWN, MOTTLED GRAY.
-15, 8	7	S-6 1 JAR SHELBY TUBE	3.0"	6.5 TO 8.5'		PUSHED SHELBY TUBE FROM 6.5 TO 8.5' RECOVERED ONLY 9" - SAMPLE PLACED IN JAR S-6	CLAYEY SAND, COARSE TO FINE SAND, PREDOMINATELY MEDIUM TO FINE SAND, ONE GRAVEL SIZE PARTICLE TO 0.13', LOW PLASTICITY, GRAY, SATURATED SOFT, SC.
10, 40	8, 9					DROVE 4" CASING FROM 6.5' TO 10.0'. WASHED CASING OUT USING SIDE-DISCHARGE CHOPPING BIT.	
12	10	S-7 1 JAR	$1\frac{3}{8}$"	10.0 TO 11.5'	3, 5, 8	DROVE $1\frac{3}{8}$" x 24" SPLIT-SPOON SAMPLER FROM 10.0 TO 11.5' RECOVERED 18"	SANDY PEAT, SMALL ROOTS, SLIGHT ORGANIC ODOR, 20-30% FINE SAND, SATURATED, DARK BROWN, Pt.
23, 32	11, 12					DROVE 4" CASING FROM 10.0 TO 13.0' WASHED CASING OUT USING SIDE-DISCHARGE CHOPPING BIT. DROVE $1\frac{3}{8}$" x 24" SPLIT-SPOON SAMPLER FROM 13.0 TO 14.5' RECOVERED 12"	
72	13	S-8 1 JAR	$1\frac{3}{8}$"	13.0 TO 13.5	17		SAND, COARSE TO FINE SAND, 10-15% FINE SUBANGULAR GRAVEL 10-15% PEAT, SLIGHT ORGANIC ODOR DARK BROWN, SATURATED, SP.

Site: EAST DART BASIN SANDWICH, MA	Boring No. FD-1	Page 3 of 7

DEPTH: Blows on Casing	DEPTH: 1" = 1'	CORE/SAMPLE: NO.	SIZE	DEPTH RANGE	BLOWS PER FT. / CORE RECVY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
		S-8	1 3/8"	13.0 TO 14.5'	29		SAND, COARSE TO FINE SAND 10-15% FINE SUBANGULAR GRAVEL 10-15% PEAT, SLIGHT ORGANIC ODOR, DARK BROWN, SATURATED SP. TIP OF SAMPLER CLAYEY SILT
132	14	1 JAR			37		
300 lb						DROVE 4" CASING FROM 13.0 TO 20.0'. WASHED OUT CASING USING SIDE DISCHARGE CHOPPING BIT. NO SAMPLING WAS PERFORMED FROM 14.5 TO 20.0 Ft DUE TO AN ERROR. A 5Ft SECTION OF CASING WAS ADDED TO THE 2Ft OF CASING REMAINING ABOVE GROUND FOLLOWING THE SAMPLING AT 13.0Ft. THE FULL 7 Ft OF CASING REMAINING ABOVE GROUND WAS MISTAKENLY DRIVEN TO 20.0 Ft. BECAUSE OF THIS ERROR CAREFUL MONITORING OF THE WASH WATER WAS MADE TO DETECT ANY SIGNIFICANT CHANGE IN THE SUBSOIL. SINCE NO CHANGES WERE DETECTED BETWEEN THE WASH AND THE SAMPLE RECOVERED FROM 20.0 TO 22.0 Ft OR WITHIN THE RANGE FROM 14.5 TO 20.0 Ft. THE DECISION NOT TO RELOCATE THE BORING AND SAMPLE AT 15.0Ft WAS MADE.	WASH - CLAYEY SILT
69	15						
440 lb							
89	16						
440 lb							
124	17						
440 lb							
162	18						
440 lb							
83	19						
440 lb							
97	20	S-9	1 3/8"	20.0 TO 22.0'	10	DROVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 20.0 TO 22.0'. RECOVERED 14"	CLAYEY SILT, LOW PLASTICITY 10-15% FINE SAND, <5% INTERSPERSED COARSE SAND, SATURATED GRAY, ML.
300 lb		1 JAR			11		
98	21				14		
300 lb	22				26		

Site: EAST BOAT BASIN
SANDWICH, MA

Boring No. FD-1

DEPTH: Blows on Casing	DEPTH: 1" = 1'	CORE/SAMPLE: NO.	CORE/SAMPLE: SIZE	CORE/SAMPLE: DEPTH RANGE	BLOWS PER FT. / CORE RECVY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
100 300 lb							
36 440 lb	23						
129 440 lb	24					7-20-81 DROVE CASING FROM 20.0 TO 25.0' WASHED OUT CASING USING ROLLER BIT.	
181 440 lb	25						
158 440 lb		S-10 1 JAR	1 3/8"	25.0 TO 26.5	50 100	DROVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 25.0 TO 26.5,	CLAYEY SILT, LOW PLASTICITY, 10-15 % FINE SAND, 10% FINE GRAVEL AND COARSE SAND INTERSPERSED, SATURATED, GRAY ML. POSSIBLE SMALL COBBLE AT 25.5'
150 440 lb	26				17/300 lb		
203 440 lb	27					DROVE 4" CASING FROM 25.0 TO 30.0' WASHED OUT CASING USING ROLLER BIT. HOLE WAS WASHED TO 31' AND REMAINDER OPEN 1' BELOW BOTTOM OF CASING	
206 440 lb	28						
252 440 lb	29						
130 300 lb 30-31'	30						

1230

D... 58A(Test)

Boring No. FD-1

DEPTH: Blows on Casing	DEPTH: 1" = 1'	CORE/SAMPLE: NO.	SIZE	DEPTH RANGE	BLOWS PER FT. CORE RECV'Y	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
130 300 lb 30-31'							
126 440 lb	31	S-11 1 JAR	1 3/8"	31.0 TO 32.5	10 14	DROVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 31.0 TO 32.5'. RECOVERED 10"	CLAYEY SILT, LOW PLASTICITY SATURATED, GRAY, ML.
100 440 lb	32				17	DROVE 4" CASING FROM 30.0 TO 33.0'. WASHED OUT CASING USING ROLLER BIT	
84 440 lb	33					ATTEMPTED TO PUSH SHELBY TUBE AT 33.0'. THE TUBE COULD NOT BE ADVANCED AT ALL AND WHEN RETRIVED THE TIP OF THE TUBE WAS BENT, MOST PROBABLY DUE TO A PIECE OF FINE GRAVEL.	
104 440 lb	34						
201 440 lb	35					CASING DRIVEN FROM 33.0 TO 36.0'. CASING WASHED OUT USING ROLLER BIT.	
134 440 lb	36	S-12 1 JAR	1 3/8"	36.0 TO 38.0'	21 22	DROVE 1 3/8" x 24" SPLIT SPOON SAMPLER FROM 36.0 TO 38.0'. RECOVERED 2" IN TIP OF SAMPLER	CLAYEY SILT, LOW PLASTICITY SATURATED, GRAY, ML.
131 440 lb	37				19 25		
129 440 lb	38						
	39						

1325

Site: EAST BOAT BASIN
SANDWICH, MA

Boring No. FD-1

Blows on Casing	Depth 1" = 1'	Core/Sample No.	Size	Depth Range	Blows per ft. Core Rec'vy	Sampling and Coring Operations	Classification of Materials
120 440 lb						7-21-81 DROVE 4" CASING FROM 31.0 TO 41.0' WASHED OUT CASING USING ROLLER BIT. WASHED TO 42.0' HOLE REMAINED OPEN.	
106 440 lb	40						
103 440 lb	41						
111 440 lb	42	S-13 1 JAR	1 3/8"	42.0 TO 43.5'	28 37	DROVE 1 3/8 x 24" SPLIT-SPOON SAMPLER FROM 42.0 TO 43.5' RECOVERED 1.5" IN TIP OF SPOON.	SILTY SAND, COARSE TO FINE SAND, 15-25% NONPLASTIC FINE - MAYBE SLIGHTLY PLASTIC SEVERAL GRAINS OF FINE GRAVEL SATURATED, GRAY SM.
135 440 lb	43				26	REDROVE SAMPLER TO 46.0 FOR RECOVERY. NO RECOVERY	
104 440 lb	44						
113 440 lb	45						
136 440 lb	46						
149 440 lb 47-48'	47						

Site: EAST BOAT BASIN SANDWICH, MA	Boring No. FD-1	Page 7 of 7

DEPTH: BLOWS ON CASING	DEPTH: 1" =	CORE/SAMPLE: NO.	CORE/SAMPLE: SIZE	CORE/SAMPLE: DEPTH RANGE	BLOWS PER FT. / CORE RECV'Y	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
149 400 lb 47-48'	48					DROVE 4" CASING FROM 42.0 TO 47.0'	
		S-14 1 JAR	1 3/8"	48.0 TO 50.0'	12	CASING WASHED OUT USING ROLLER BIT, CASING DRIVEN TO 48.0'	GRAVELLY SAND, COARSE TO FINE SAND, COARSE TO FINE GRAVEL to 0.12' max 10-20% non-plastic fines, sat. gray SP
					10	DROVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 48 TO 50.0'	
	49				23	RECOVERED 3" IN TIP OF SAMPLER	
	50				25	BOTTOM OF BORING 50.0'	

58A(Test)

Boring No: FD-1

SUBSURFACE WATER OBSERVATIONS

DATE	TIME	DEPTH-BOT. OF CASING	DEPTH-BOT. OF BORING	DEPTH TO WATER	ELEVATION WATER	REMARKS
7-21-81	1340	15.0'	50.0	11.2'	8.9' M.S.L.	BECAUSE THE CASING WAS IN CLAYEY SILT AND
						REMAINED FULL OF WATER THE WATER LEVEL COULD NOT
						BE MEASURED UNTIL THE
						CASING WAS REMOVED TO A LEVEL ABOVE THE
						IMPERVIOUS SOIL.

Note: Depths are in feet below original ground

BORING LOCATION SKETCH

FOR BORING LOCATION SEE SITE PLAN

FORM 59(Test)

Boring No. FD-1

U. S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION	Site EAST BOAT BASIN Page 1 of 4 Pages
FIELD LOG OF TEST BORING	Boring No. FD-2 Desig. 5 Diam. (Casing) HW 4"
	Co-ordinates: N ______ E ______

Elevation Top of Boring ± 18.0 Ft M.S.L.
Total Overburden Drilled 50.0 Feet
Elevation Top of Rock NONE ENCOUNTERED M.S.L.
Total Rock Drilled NONE Feet
Elevation Bottom of Boring -32.0 Ft M.S.L.
Total Depth of Boring 50.0 Feet
Core Recovered N/A % No. Boxes ______
Core Recovered N/A Ft : ______ Diam. ______ In.
Soil Samples 1 3/8 In. Diam. 10 No.
Soil Samples 4" + WASH SAMP. In. Diam. 2 No.

Hammer Wt. 140 lb Boring Started 7-21-81
Hammer Drop 30 in.
Boring Completed 7-23-81
Casing Left NONE
Subsurface Water Data ______ Page ______
Obs. Well NONE
Drilled By BRIGGS ENGINEERING & TESTING Co.
Mfg. Des. Drill ACKER
Inspected By: RONALD F. BUZACKI
Classification By: ______
Classification By: ______

DEPTH: Blows on casing	DEPTH: 1" = 2'	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
4	0–1	S-1 1 JAR	1 3/8"	0.0 0.5'	3	DROVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 0.0 TO 1.5'!	SURFACE: TALL MARSH GRASS AND BRUSH, COBBLES VISIBLE ON SURFACE TO 2' DIA. EST. 5%
		S-2 1 JAR	1 3/8"	0.5 TO 1.5'	5 6	RECOVERED 18"	TOPSOIL: TOP 1-2" ORGANIC MATERIAL, WOOD, DECAYING LEAVES, ETC. SILTY SAND, COARSE TO FINE SAND, PREDOMINATELY MEDIUM TO FINE, 10-20% NONPLASTIC FINES, 10-20% COARSE TO FINE GRAVEL, MOIST, BROWN, SM.
8	1–2					DROVE 4" CASING FROM 0.0 TO 5.0'. REMOVED AND EMPTIED	
19	2–3					PLACED SAMPLE FROM 4.7 TO 5.0' IN SAMPLE JAR S-3.	
23	3–4					HOLE REMAINED OPEN.	SILTY SAND, COARSE TO FINE SAND, PREDOMINATELY M & F, 15-25% NONPLASTIC FINES 10-20% COARSE TO FINE SUBANGULAR GRAVEL, MOIST, BROWN, SM.
29	4–5	S-3	4"	4.7 5.0'			
27	5–6	S-4	1 3/8"	5.0 TO 5.8'	10 11	DROVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 5.0 TO 6.5'	INTERBEDDED ORGANIC SILT, SILTY SAND, AND SILT, MOIST
32	6–7	S-5	1 3/8"	5.8 TO 6.5'	12	RECOVERED 18" 7-22-81 DROVE 4" CASING FROM 5.0 TO 10.0'	GRAVELLY SAND, COARSE TO FINE SAND, 20-25% FINE SUBANGULAR GRAVEL, 10-15% NONPLASTIC FINES, SATURATED, BROWN, SP
44	7–8					WASHED OUT CASING USING ROLLER BIT.	S-5 SILTY SAND, MEDIUM TO FINE SAND, 10-20% NONPLASTIC FINES, <5% FINE GRAVEL PARTICLES INTERSPERSED, MOIST, DARK GRAYISH BROWN, SM.
48	8–9						
97	9–10						

GENERAL REMARKS: BORING DEPTHS ARE REFERENCED FROM EXISTING SURFACE ELEVATION. BLOWS ON CASING FROM 300 lb HAMMER, UNLESS OTHERWISE NOTED, DROPPED 18 in.

NED FORM 58 (Test) Boring No. FD-2

Site: EAST BOAT BASIN SANDWICH, MA	Boring No. FD-2	Page 2 of 4

Blows on Casing	Depth (1" = 2')	Core/Sample No.	Size	Depth Range	Blows per ft. / Core Recv'y	Sampling and Coring Operations	Classification of Materials
48	10–11	S-6 1 JAR	1 3/8"	10.0 to 11.5'	4 / 12 / 27	DROVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 10.0 TO 11.5' RECOVERED 10"	GRAVELLY SAND, COARSE TO FINE SAND, 20-25 % FINE GRAVEL, 10-20 % NONPLASTIC FINES, SATURATED, BROWN, SP.
77	11–12						
67	12–13					DROVE 4" CASING FROM 10.0 TO 15.0' WASHED OUT CASING USING ROLLER BIT.	
71	13–14						
73	14–15						
32	15–16	S-7 1 JAR	—	15.0 TO 18.0'	8 / 11 / 15	DROVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 15.0 TO 16.5' RECOVERED ONE COARSE GRAVEL SIZE PARTICLE. REDROVE SAMPLER FOR RECOVERY FROM 15.0 TO 18.0'. NO RECOVERY SAMPLE TAKEN FROM WASH WATER, INCLUD. GRAVEL PARTICLE FROM FIRST SAMPLING ATTEMPT.	WASH FROM CASING: SAND, MEDIUM TO FINE ESTIMATE <10 % FINES BROWN, SP.
42	16–17	SAMPLE TAKEN FROM WASH WATER					
45	17–18						
53	18–19						
48	19–20						
46	20–21	NO RECOVERY			11 / 11 / 11	DROVE 4" CASING FROM 15.0 TO 20.0' AND WASHED OUT CASING USING ROLLER BIT	
52	21–22						
53	22–23					DROVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 20.0 TO 21.5'. NO RECOVERY TWO MORE ATTEMPTS FOR RECOVERY WERE MADE WITHOUT SUCCESS. DROVE 4" CASING FROM 20.0 TO 25.0	
64	23–24						
90 4/10	24–25						SMALL COBBLE PUSHED BY CASING AT 24.5'
83	25–26	S-8	1 3/8"	26.0 TO 27.5'	Cobble / Cobble / 23 / 26	WASHED CASING OUT USING ROLLER BIT. SMALL COBBLE AT TIP OF CASING. BROKE THROUGH WITH SPLIT-SPOON AT 26.0'.	SILTY SAND, MEDIUM TO FINE SAND, 15-20% SLIGHTLY PLASTIC FINES, SATURATED, GRAY SM. (SOIL POSSIBLY CLAYEY SAND)
86	26–27						

1200

BBA (Test) Boring No. FD-2

Site: EAST BOAT BASIN SANDWICH, MA	Boring No. FD-2	Page 3 of 4

DEPTH: Blows on Casing	DEPTH: ft. 2'	CORE/SAMPLE: NO.	CORE/SAMPLE: SIZE	CORE/SAMPLE: DEPTH RANGE	BLOWS PER FT. / CORE RECV'Y	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
66					30	RECOVERED 10"	
73	28					DROVE 4" CASING FROM 25.0 TO 30.0 WASHED OUT CASING USING ROLLER BIT,	
100	29					SMALL COBBLE ENCOUNTERED AT TOP OF CASING. 300 lb HAMMER USED TO BREAK.	SMALL COBBLE AT 30'
72	30	S-9 1 JAR	1 3/8"	30.0 TO 32.0'	20 300 lb / 35	DROVE 1 3/8 x 24" SPLIT-SPOON SAMPLER FROM 30 TO 32.0'	CLAYEY SILT, LOW PLASTICITY MOIST, < 5% COARSE SAND INTERSPERSED, GRAY, ML.
91	31				37 / 54	DROVE CASING FROM 30.0 TO 33.0 FT.	
93 440 lb	32					7-23-81	
500 440 lb	33					DROVE CASING 33.0 TO 34.0' WASHED OUT CASING USING ROLLER BIT TO 34.0' COBBLE ENCOUNTERED AT 34.0'.	
372 440 lb	34	BOULDER BUSTER 300 lb HAMMER 18" DROP			27 / 31	DRIVE BOULDER BUSTER TO CLEAR PATH USING 300 lb HAMMER. REINSERTED ROLLER BIT AND DRILLED FROM 34 TO 35.0'	COBBLE ENCOUNTERED AT 34'
479 440 lb	35	S-10 1 JAR	1 3/8"	35.0 TO 36.5'	24 / 27 / 43	DRIVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 35.0 TO 36.5' RECOVERED 16"	CLAYEY SILT WITH HORIZONTAL SEAMS TO 1/2" OF MEDIUM SAND AT 4 TO 6" INTERVALS, LOW PLASTICITY, MOIST, GRAY, ML.
	36						
	37					DROVE 4" CASING FROM 34 TO 36' AND WASHED OUT AND AHEAD OF CASING USING ROLLER BIT, TO 40.0 FT. HOLE REMAINED OPEN	SMALL COBBLE IN CASING AT 36'
	38						
	39						
	40	S-11 1 JAR	1 3/8"	40.0 TO 41.5'	33 / 56 / 40	DROVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 40.0 TO 41.5'. RECOVERED 8."	SILTY SAND, COARSE TO FINE SAND, PREDOMINATELY MEDIUM TO FINE SAND, 10-20% NONPLASTIC FINES, <10% FINE GRAVEL INTERSPERSED, ROCK FRAGMENTS ALSO RECOVERED, SATURATED, GRAY, SM.
	41						
	42					WASHED OUT HOLE FROM 40.0 TO 45.0' USING ROLLER BIT. HOLE REMAINED OPEN. WHEN SAMPLER WAS PLACED DOWN THE HOLE THE TIP CAME TO 44'.	
	43						
	44						

1215

Site: EAST BOAT BASIN SANDWICH, MA	Boring No. FD-2	Page 4 of 4

DEPTH: Blows on Casing	DEPTH: 1" = 2'	CORE/SAMPLE: No.	CORE/SAMPLE: Size	CORE/SAMPLE: Depth Range	BLOWS PER FT. / CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
	45, 46					THE SAMPLER WAS REMOVED AND THE HOLE REWASHED USING THE ROLLER BIT. THE OBSTRUCTING MATERIAL WAS WASHED CLEAR, HOWEVER THE ROLLER BIT QUICKLY PENETRATED TO 47'. SAMPLING WAS ACCOMPLISHED AT 47.0'.	
	47, 48, 49	S-12 1 JAR	1 3/8"	47.0 TO 50.0'	39, 34, 47, 40, 45, 50	DROVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 47.0 TO 48.5 WITH NO RECOVERY. REDROVE SPLIT-SPOON SAMPLER FROM 48.5 TO 50.0' RECOVERED 10".	SAND, MEDIUM TO FINE SAND <10 % NONPLASTIC FINES, <5 % FINE GRAVEL, SATURATED, BROWN AND RUSTY BROWN, ST.
	50					BOTTOM OF BORING AT 50'	

Site: EAST BOAT BASIN, SANDWICH
Boring No: FD-2

SUBSURFACE WATER OBSERVATIONS

DATE	TIME	DEPTH-BOT. OF CASING	DEPTH-BOT. OF BORING	DEPTH TO WATER	ELEVATION WATER	REMARKS
7-23-81	1545	10.0' *	50.0'	9.7'	8.3 Ft M.S.L.	

Note: Depths are in feet below original ground
* Because the casing was seated in clayey Silt, it remained full of water. The water level could not be measured until the casing was removed above this impervious soil.

BORING LOCATION SKETCH

SEE SITE PLAN WITH BORING LOCATIONS

FORM 59(Test)

Boring No. FD-2

CORPS OF ENGINEERS
NEW ENGLAND DIVISION

33

FIELD LOG OF TEST BORING

Boring No. FD-3 Desig. 1 Diam. (Casing) 4.0" HW

Co-ordinates: N ______ E ______

Elevation Top of Boring 17.1 Ft M.S.L.
Total Overburden Drilled 20.0 Feet
Elevation Top of Rock ______ M.S.L.
Total Rock Drilled ______ Feet
Elevation Bottom of Boring -2.9' M.S.L.
Total Depth of Boring 20.0 Feet
Core Recovered 45 % No. Boxes JAR C-1
Core Recovered 0.9 Ft : 1 3/8" Diam. ____ In.
Soil Samples 1 3/8 In. Diam. 6 No.
Soil Samples ______ In. Diam. ____ No.

Hammer Wt. 140 lb Boring Started 7-13-81
Hammer Drop 30 in.
Boring Completed 7-14-81
Casing Left NONE
Subsurface Water Data ______ Page ______
Obs. Well NONE
Drilled By BRIGGS ENGINEERING & TESTING Co.
Mfg. Des. Drill ACKER
Inspected By: RONALD F. BUKAREL
Classification By: ______
Classification By: ______

DEPTH: Blows on Casing	DEPTH: 1" = 2'	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. / CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
42	0	S-1 1 JAR	1 3/8"	0.0 TO 0.8	6	DROVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 0.0 TO 1.5'	GROUND SURFACE: <10% COBBLES TO 1.0' DIA.
					19		
38	1	S-2 1 JAR	1 3/8"	0.8 TO 1.5'	19	RECOVERED 1.5'	TOPSOIL: SILTY SAND, FINE SAND, 35 TO 45% NONPLASTIC FINES, <15% FINE GRAVEL DAMP, DARK BROWN, SM.
38	2					DROVE 4" CASING 0.0 TO 5.0' REMOVED, HOLE REMAINED OPEN.	
30	3						SILTY SAND, COARSE TO FINE SAND, PREDOMINATELY FINE SAND, 25-35% NONPLASTIC FINES, <15% SUBANGULAR FINE GRAVEL, DAMP, BROWN, SM.
43	4						
13	5	S-3 1 JAR	1 3/8"	5.0 TO 6.5'	6	DROVE 1 3/8" x 24" SPLIT-SPOON SAMPLER FROM 5.0 TO 6.5' RECOVERED 0.6'	SILTY SAND, COARSE TO FINE SAND, PREDOMINATELY MEDIUM TO FINE SAND, 15-20% NONPLASTIC FINES, <15% FINE SUBANGULAR GRAVEL, MOIST TO VERY MOIST, BROWN, SM.
					8		
18	6				18		
16	7					DROVE 4" CASING FROM 5' TO 10' WASHED OUT CASING USING ROLLER BIT.	
18	8						WASH BECAME GRAYISH BROWN AT APPROXIMATELY 9.0'
34	9						
	10						

0915

0 1000

GENERAL REMARKS: REFUSAL; 100 BLOWS < 1.0' PENETRATION FOR FINAL 1.0' OF SPLIT-SPOON PENETRATION.
CASING DRIVEN USING 300 lb HAMMER DROPPED 18 in.
BLOWS ON CASING FROM 300 lb HAMMER, DROPPED 18 in.

NED ... .58(Test)

Boring No. FD-3

Site: East Boat Basin, Sandwich, MA	Boring No. FD-3	Page 2 of 2

	DEPTH: Blows on Casing	DEPTH: 1" = 2'	CORE/SAMPLE: No.	CORE/SAMPLE: Size	CORE/SAMPLE: Depth Range	Blows per ft. / Core Recv'y	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
1130	40		S-4 1 JAR	1 3/8"	10 to 11.5'	4	DROVE 1 3/8 x 24" SPLIT-SPOON SAMPLER FROM 10 TO 11.5'	SILTY SAND, MEDIUM TO FINE SAND, 15-25% NONPLASTIC FINES, INTERBEDDED SEAMS OF FINES TO 0.1' THICK, <15% SUBANGULAR FINE GRAVEL, MOIST TO VERY MOIST, GRAYISH BROWN, SM.
		11				19	RECOVERED 0.8'	
	50					30		
		12					DROVE 4" CASING FROM 10-15'	
	64						WASHED OUT CASING USING ROLLER BIT.	
		13						
	67							
		14						
	73							
1245	117	15	S-5 1 JAR	1 3/8"	15 to 16.5'	10	DROVE 1 3/8 x 24" SPLIT-SPOON SAMPLER FROM 15 TO 16.5'	GRAVELLY SAND, COARSE TO FINE SAND, 15-20% FINE SUBANGULAR GRAVEL, 10-15% NONPLASTIC FINES, ROCK FRAGMENTS RECOVERED IN TIP OF SPOON, SATURATED, GRAYISH BROWN, SP.
1405		16				29	RECOVERED 0.3', ROCK FRAGMENTS IN TIP OF SPOON.	
1410 - RAIN TO 1445						118		
		17	C-1 1 JAR	1 3/8"	16.5 to 18.3'		DROVE CASING FROM 15.0 TO 16.3', ENCOUNTERED OBSTRUCTION. USED ROLLER BIT TO ATTEMPT TO GET BY OBSTRUCTING ROCK, NO SUCCESS.	BOULDER 16.3 TO 18.3'
		18						
1530		19	S-6 1 JAR	1 3/8"	18.5 to 20.0'	55	CORED FROM 16.5 TO 16.8' THEN CORE TIP BECAME PLUGGED AND NO WATER WOULD FLOW REMOVED 5' CLEANED.	SILTY SAND, COARSE TO FINE SAND, PREDOMINATELY MEDIUM TO FINE SAND, 15-25% NONPLASTIC FINES
						58		
		20				70	REINSERTED AND CORED FROM	
7-14-81 1500 hrs							16.8 TO 18.3' RECOVERED 0.8' OF 1 3/8" CORE	<10% FINE SUBANGULAR GRAVEL, SATURATED, GRAYISH BROWN, SM.
		21					DROVE 18" x 1 3/8 SPLIT-SPOON SAMPLER FROM 18.5 TO 20.0'	BOTTOM OF BORING 20.0 ft.
		22					RECOVERED 18".	
		23					ATTEMPTED TO BREAK BOULDER USING BOULDER BUSTER.	
		24					THE ATTEMPT WAS UNSUCCESSFUL	
		25						
		26						
		27						

Site: East Boat Basin
Boring No: FD-3

SUBSURFACE WATER OBSERVATIONS

DATE	TIME	DEPTH-BOT. OF CASING	DEPTH-BOT. OF BORING	DEPTH TO WATER	ELEVATION WATER	REMARKS
7-14-81	0810	16.3'	20.0'	8.8'	8.3' M.S.L	TIDE +6.3' M.L.W.

Note: Depths are in feet below original ground

BORING LOCATION SKETCH

SEE BORING PLAN.

FORM 59(Test)

Boring No. FD-3

U.S. ARMY CORPS OF ENGINEERS NEW ENGLAND DIVISION	Site EAST BOAT BASIN Page 1 of 2 Pages
FIELD LOG OF TEST BORING	Boring No. FD3A Desig. 1A Diam. (Casing) HW, 4"
	Co-ordinates: N ______ E ______

Elevation Top of Boring	17.1 M.S.L.	Hammer Wt.	140
Total Overburden Drilled	22.0 Feet	Hammer Drop	30 in
Elevation Top of Rock	NONE ENCOUNTERED M.S.L.	Casing Left	NONE
Total Rock Drilled	NONE Feet	Subsurface Water Data	______ Page ______
Elevation Bottom of Boring	-4.9' M.S.L.	Obs. Well	NONE
Total Depth of Boring	22.0' Feet	Drilled By	BRIGGS ENGINEERING & TESTING CO.
Core Recovered	N/A % No. Boxes ______	Mfg. Des. Drill	ACKER
Core Recovered	N/A Ft: ______ Diam. ______ in.	Inspected By:	RONALD F. BUKOSKI
Soil Samples	1 3/8 in. Diam. 0 No.	Classification By:	
Soil Samples	______ in. Diam. ______ No.	Classification By:	
Boring Started	7-14-81	Boring Completed	7-14-81

DEPTH: Blows on Casing	DEPTH 1" = 2'	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. CORE RECV'Y	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
	1					BORING FD-3A RELOCATED 6 Ft CLOSER TO THE SERVICE ROAD, ON A LINE PERPENDICULAR TO THE ROAD DUE TO AN OBSTRUCTING BOULDER IN FD-3	
	2						
	3					CASING DRIVEN TO 20.0', WITH INTERMEDIATE WASHING OUT AS NECESSARY.	
	4						
	5						
	6						
	7						
	8						
	9						
	10						

GENERAL REMARKS: REFUSAL: 100 BLOWS < 1Ft PENETRATION FOR FINAL 1.0 Ft OF SPLIT-SPOON PENETRATION.
BLOWS ON CASING; 300 lb HAMMER DROPPED 18 in.

NED FORM 58 (Test) Boring No. FD-3A

Site: EAST BOAT BASIN SANDWICH, MA	Boring No. FD-3A	Page 2 of 2

DEPTH		CORE/SAMPLE			BLOWS PER FT. / CORE RECV'Y	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
BLOWS ON CASING	1" = 2'	NO.	SIZE	DEPTH RANGE			
	11						
	12						
	13						
	14						
	15						
	16						
133							
	17						
230							
	18						
200 440 lb							
	19						
182 440 lb						SMALL COBBLE ENCOUNTERED AT 20.0'	WASH APPEARED TO BE SAME AS S-6 FROM FD-3
	20					DROVE SPLIT-SPOON	SILTY SAND, COARSE TO FINE SAND, PREDOMINATELY MEDIUM TO FINE,
	21	NO RECOVERY			13	SAMPLER FROM 20.5 TO	15-25% NONPLASTIC FINES,
					40	22.0'. REFUSAL AT 22.0' NO RECOVERY	<10% FINE SUBANGULAR GRAVEL, SATURATED, GRAYISH BROWN, SM.
	22				68	BOTTOM OF BORING 22.0'	

FD-3A

U. S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

FIELD LOG OF TEST BORING

Site EAST BOAT BASIN, SANDWICH, MA Page 1 of 2 Pages
Boring No. FD-4 Desig. 2 Diam. (Casing) 4.0" HW
Co-ordinates: N ________ E ________

Elevation Top of Boring ≈ +17.2 ft M.S.L.
Total Overburden Drilled 13.5 Feet
Elevation Top of Rock NONE ENCOUNTERED M.S.L.
Total Rock Drilled NONE Feet
Elevation Bottom of Boring +3.7 ft M.S.L.
Total Depth of Boring 13.5 Feet
Core Recovered N/A % No. Boxes ____
Core Recovered N/A Ft: ____ Diam. ____ In.
Soil Samples 1 3/8 In. Diam. 5 No.
Soil Samples 3.0 In. Diam. 3 No.

Hammer Wt. 140 lb Boring Started 7-14-81
Hammer Drop 30 in. Boring Completed 7-15-81
Casing Left NONE
Subsurface Water Data ____ Page ____
Obs. Well NONE
Drilled By BRIGGS ENGINEERING & TESTING Co.
Mfg. Des. Drill ACKER
Inspected By: RONALD F. BUKASKI
Classification By: ____
Classification By: ____

1515

1535

-15-81
1825

DEPTH: Blows on Casing	DEPTH: 1" = 2'	CORE/SAMPLE: No.	Size	Depth Range	Blows per ft. / Core Rec'vy	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
17		S-1 1 JAR	1 3/8"	0.0 to 1.3	3, 5	DROVE 24" x 1 3/8" SPLIT SPOON SAMPLER FROM 0.0 TO 1.5'	SURFACE: SMALL DUNES + TALL GRASS. TOPSOIL: SILTY SAND, FINE SAND, 20-35% NONPLASTIC FINES & ORGANIC FINES, 5-10% ROOTS TO 1/4", DAMP, DARK BROWN, SM.
18	1	S-2 1 JAR	1 3/8"	1.3 to 5.0'	5	RECOVERED 18" DROVE CASING FROM 0.0 TO 5.0' REMOVED AND HOLE REMAINED OPEN.	SAND, FINE SAND, 5-15% NONPLASTIC FINES, DAMP, SANDY BROWN WITH STREAKS OF RUSTY BROWN, SP.
22	2						
23	3						
20	4						
12	5	S-3 1 JAR	1 3/8"	5.0 to 5.5'	4	DROVE SPLIT-SPOON SAMPLER FROM 5.0 TO 6.5'	SANDY SILT, LOW PLASTICITY, 10-20% FINE SAND, DAMP, BROWN, ML.
11	6	S-4 1 JAR	1 3/8"	5.5 to 6.5'	6, 6	RECOVERED 18" CASING DRIVEN TO 7.0' AND WASHED OUT	CLAYEY SILT, LOW PLASTICITY, MOIST, GRAY MOTTLED RUSTY BROWN, ML.
2	7	S-5	3.0"	7.0-7.2'		3" x 30" SHELBY TUBE PUSHED FROM 7.0 TO 9.0'. TUBE TIP BENT WOOD CHIPS & PEAT IN TIP. RECOVERED 0.3', RECOVERED SOIL PLACED IN S-5 & S-6	MUCK, WOOD CHIPS, ROOTS, PEAT MEDIUM TO FINE SAND, SATURATED SLIGHT ORGANIC ODOR, DARK BROWN.
4	8	S-6	3.0"	7.2' to 10.6'		CASING DRIVEN TO 20' AND WASHED OUT USING SIDE-DISCHARGE CHOPPING BIT. AT 9.0' COULD NOT FILL CASING WITH WATER - FLOWED OUT BOTTOM.	
3	9						
	10						

GENERAL REMARKS: DEPTHS ARE REFERENCED TO EXISTING GROUND SURFACE.
REFUSAL: 100 BLOWS < 1.0' PENETRATION.
BLOWS ON CASING: 300 lb HAMMER DROPPED 18 in.

[illegible] 58 (Test) Boring No. FD-4

Site: EAST BOAT BASIN SANDWICH, MA	Boring No. FD-4	Page 2 of

DEPTH: BLOWS ON CASING	DEPTH: 1" = 2'	CORE/SAMPLE: NO.	CORE/SAMPLE: SIZE	CORE/SAMPLE: DEPTH RANGE	BLOWS PER FT. / CORE RECV'Y	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
11		S-6	3.0"	7.2 TO 10.6'		PUSHED SECOND TUBE FROM 9.0 TO 11.0'. REMOVED TUBE -	
44	11	S-7	3.0"	10.6 TO 12.0'		BADLY DENTED FOR 1.2' FROM TIP SAMPLE DISTURBED. RECOVERED 1.0' DRIVE CASING TO 12.0' AND WASHED OUT USING SIDE-DISCHARGE CHOPPING BIT.	TRANSITION ZONE FROM MUCK TO CLAYEY SAND AND SAND
	12	S-8	1 3/8"	12.0 TO 13.5	23 / 58 / 56	DROVE 24" x 1 3/8" SPLIT SPOON FROM 12.0 TO 13.5 FT. RECOVERED 6" BOTTOM OF BORING 13.5'	GRAVELLY SAND, COARSE TO FINE SAND, 20-30% COARSE TO FINE GRAVEL, <15% NONPLASTIC FINES, SATURATED GRAYISH BROWN, SP.
	13					BORING TERMINATED AT REFUSAL, N>100	

Site: East Boat Basin
Boring No: FD-4

SUBSURFACE WATER OBSERVATIONS

DATE	TIME	DEPTH-BOT. OF CASING	DEPTH-BOT. OF BORING	DEPTH TO WATER	ELEVATION WATER	REMARKS
7-15-81	1020	12.0'	13.5'	7.1'	10.1' M.S.L.	

Note: Depths are in feet below original ground

BORING LOCATION SKETCH

See site plan for boring location.

FORM 59(Test)

Boring No. FD-4

U. S. ARMY
CORPS OF ENGINEERS
NEW ENGLAND DIVISION

FIELD LOG OF TEST BORING

Site EAST BOAT BASIN Page 1 of 4 Pages

Boring No. FD-5 Desig. 3 Diam. (Casing) HW, 4"

Co-ordinates: N ______ E ______

11.2'
TIDE + 3.5

Elevation Top of Boring	≈ +15.0 ft M.S.L.	Hammer Wt.	140 lb
Total Overburden Drilled	50.0 Feet	Hammer Drop	30 in.
Elevation Top of Rock	NOT ENCOUNTERED M.S.L.	Casing Left	NONE
Total Rock Drilled	NONE Feet	Boring Started	7-15-81
Elevation Bottom of Boring	-35.0 ft M.S.L.	Boring Completed	7-16-81
Total Depth of Boring	50.0 Feet	Subsurface Water Data	______ Page ______
Core Recovered	N/A % No. Boxes ______	Obs. Well	NONE
Core Recovered	N/A Ft: ______ Diam. ______ In.	Drilled By	BRIGGS ENGINEERING & TESTING Co.
Soil Samples	1 3/8 In. Diam. 9 No.	Mfg. Des. Drill	ACKER
Soil Samples	______ In. Diam. ______ No.	Inspected By	RONALD F. BURASEL
		Classification By	
		Classification By	

1230

DEPTH: Blows on Casing	DEPTH: 1" = 2'	CORE/SAMPLE NO.	SIZE	DEPTH RANGE	BLOWS PER FT. / CORE REC'VY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
11		S-1 1 JAR	1 3/8"	0.0 TO 1.5'	4	DRIVE SPLIT-SPOON SAMPLER FROM 0.0 TO 1.5'	SURFACE: BORING LOCATED NEAR OLD CONCRETE FLOOR SLAB. (12') GRAVELLY WITH GRASS.
	1				18	RECOVERED 18"	
24					18	DROVE 4" CASING FROM 0.0 TO 5.0'. ENCOUNTERED SOME DIFFICULTIES IN VERTICALLY ALIGNING CASING DUE TO COBBLES WITHIN FIRST 5'.	SILTY SAND, COARSE TO FINE SAND, PREDOMINATELY MEDIUM TO FINE, 25-35% NONPLASTIC FINES, 5% SLIGHTLY PLASTIC CLAYEY SILT, 10-15% FRACTURED ROCK AND FINE GRAVEL, DAMP, BROWN, SM.
	2						
27							
	3					WASHED OUT CASING USING ROLLER BIT.	
16							
	4						
18							
	5						
12		S-2 1 JAR	1 3/8"	5.0 TO 6.5'	5	DROVE SPLIT-SPOON SAMPLER FROM 5.0 TO 6.5'.	SILTY SAND, COARSE TO FINE SAND, 30-40% SLIGHTLY PLASTIC FINES, <10% FINE GRAVEL, <2% WOOD FRAGMENTS, MOIST, DARK GRAYISH BROWN, SM.
	6				7	RECOVERED 9".	
15					14		
	7					DROVE CASING FROM 5.0 TO 10.0'.	
18							
	8					WASHED OUT CASING USING ROLLER BIT. CASING SETTLED TO 11.0'	
14							
	9						
23							
	10						

GENERAL REMARKS: DEPTHS ARE REFERENCED TO EXISTING GROUND SURFACE. REFUSAL: 100 BLOWS < 1.0' PENETRATION. BLOWS ON CASING: 300 lb HAMMER 18 in. DROP HEIGHT.

NED FORM 58(Test) Boring No. FD-5

Site: EAST BOAT BASIN	Boring No. FD-5	Page 2 of 4

Blows on Casing	Depth Fr. 2'	Core/Sample No.	Size	Depth Range	Blows per ft. Core Rec'vy	Sampling and Coring Operations	Classification of Materials
19							
41	11	S-3 1 JAR	1 3/8"	11.0 TO 12.5'	12 14 17	DROVE SPLIT-SPOON SAMPLER FROM 11.0 TO 12.5' RECOVERED 13."	SILTY SAND, MEDIUM TO FINE SAND, 25-35% SLIGHTLY PLASTIC FINES, <5% FINE GRAVEL, DAMP, GRAYISH BROWN MOTTLED DARK BROWN AND RUSTY BROWN, SM.
62	12						
73	13					DROVE 4" CASING FROM 11.0 TO 15.6'.	
82	14					WASHED CASING OUT USING ROLLER BIT. CASING SETTLED 0.5'	
54	15						
46	16	S-4 1 JAR	1 3/8"	15.5 TO 17.0'	22 19 12	DROVE SPLIT-SPOON SAMPLER FROM 15.5 TO 17.0'. RECOVERED 12."	SILTY SAND, COARSE TO FINE SAND, 15-25% NONPLASTIC TO SLIGHTLY PLASTIC FINES, < 10% FINE SUBANGULAR GRAVEL, SATURATED BROWN, SM.
47	17					DROVE CASING FROM	
46	18					15.5' TO 20.0'. WASHED CASING OUT USING ROLLER BIT	
51	19						
74	20	S-5 1 JAR	1 3/8"	20.0 TO 21.5'	26 37 39	DROVE SPLIT-SPOON SAMPLER FROM 20.0 TO 21.5'. RECOVERED 6." (7-15-81)	SILTY SAND, COARSE TO FINE SAND, 10-15% NONPLASTIC FINES, 10-15% GRAVEL TO 0.12', SATURATED BROWN, TO DARK BROWN, SM.
68	21					(7-16-81)	
70	22					DROVE 4" CASING FROM 20.0 TO 25.0'.	
60	23					WASHED OUT CASING WITH SIDE-DISCHARGE CHOPPING BIT	
222	24						
91	25	S-6 1 JAR	1 3/8"	25.0 TO 26.5'	33 53 32	DROVE SPLIT-SPOON SAMPLER FROM 25 TO 26.5' RECOVERED 6."	SILTY SAND, COARSE TO FINE SAND, 10-15% NONPLASTIC FINES, 10-15% FINE GRAVEL, SATURATED, BROWN, SM.
190	26						
	27						

1600

11
31
39

-16-81
0920

Site: EAST BOAT BASIN | Boring No. FD-5 | Page 3 of 9

DEPTH: Blows on Casing	DEPTH: 1" = 2'	CORE/SAMPLE: No.	CORE/SAMPLE: Size	CORE/SAMPLE: Depth Range	BLOWS PER FT. / CORE RECV'Y	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
140 / 440#	28					DROVE 4" CASING FROM 25.0 TO 30.0'. WASHED OUT USING SIDE-DISCHARGE CHOPPING BIT.	
71 / 440#	29						
71 / 440#	30						
78 / 440#	31	S-7	1 3/8	30.0 TO 31.5'	11, 31, 39	DROVE SPLIT-SPOON SAMPLER FROM 30.0 TO 31.5'. RECOVERED 2".	SILTY SAND, COARSE TO FINE SAND, 10-20% NONPLASTIC FINES, SATURATED, BROWN, SM.
76 / 440#	32						
57 / 440#	33					DROVE 4" CASING FROM 30.0 TO 35.0'. WASHED OUT CASING USING SIDE DISCHARGE CHOPPING BIT.	
60 / 440#	34						
67 / 440#	35						
71 / 300#	36	NO RECOVERY			19, 18, 15	DROVE SPLIT-SPOON SAMPLER FROM 35.0 TO 36.5'. FIRST ATTEMPT NO RECOVERY. SECOND ATTEMPT NO RECOVERY, OVERDROVE SAMPLER TO 39'.	WASH APPEARED SAME AS ABOVE
60 / 300#	37						
54 / 300#	38						
65 / 300#	39					DROVE 4" CASING FROM 35 TO 40.0'. WASHED OUT USING SIDE-DISCHARGE CHOPPING BIT.	
78 / 300#	40						
71 / 440#	41	S-8	1 3/8	40 TO 41.5'	28, 22, 14	DROVE SPLIT SPOON SAMPLER FROM 40 TO 41.5'. RECOVERED 2".	SILTY SAND, MEDIUM TO FINE SAND, 10-20% NONPLASTIC FINES, GRAVEL PARTICLE TO 0.12', SATURATED, BROWN, SM.
55 / 440#	42						
61 / 440#	43					DROVE 4" CASING FROM 40.0 TO 45.0'. WASHED OUT CASING USING SIDE-DISCHARGE CHOPPING BIT.	
59 / 440#	44						

Site: EAST BOAT BASIN	Boring No. FD-5	Page 4 of 4

DEPTH: Blows on Casing	DEPTH: 1" = 2'	CORE/SAMPLE: NO.	CORE/SAMPLE: SIZE	CORE/SAMPLE: DEPTH RANGE	BLOWS PER FT. / CORE RECVY	SAMPLING AND CORING OPERATIONS	CLASSIFICATION OF MATERIALS
61 440#	45				29	DROVE SPLIT-SPOON SAMPLER FROM 45.0 TO 46.5'. NO RECOVERY.	
52	46				64 91	REDROVE SPOON TO 48.0 FT, NO RECOVERY	SMALL COBBLE AT 46.5'
59	47						
69	48					DROVE CASING FROM 45.0 TO 48.0' WASHED OUT CASING USING SIDE DISCHARGE CHOPPING BIT.	
	49	S-9	1 3/8	48.0 TO 50.0'	20 46 36 57	DROVE SPLIT-SPOON SAMPLER FROM 48.0 TO 50.0 RECOVERED 4"	SANDY GRAVEL, FINE SUBANGULAR GRAVEL, 30-40 % COARSE TO FINE SAND, 5-10 % NONPLASTIC FINES, SATURATED, BROWN, GP.
	50					BOTTOM OF BORING 50.0'	

Site: EAST BOAT BASIN, SANDWICH, MA Boring No: FD-5	SUBSURFACE WATER OBSERVATIONS

DATE	TIME	DEPTH-BOT. OF CASING	DEPTH-BOT. OF BORING	DEPTH TO WATER	ELEVATION WATER	REMARKS
7-16-81	0745	20.0'	21.5'	11.2'	3.8' M.S.L.	TIDE +3.3'
7-17-81	0715	48.0	50.0'	12.7'	2.3' M.S.L.	TIDE +1.0'

Note: Depths are in feet below original ground

BORING LOCATION SKETCH

SEE BORING PLAN

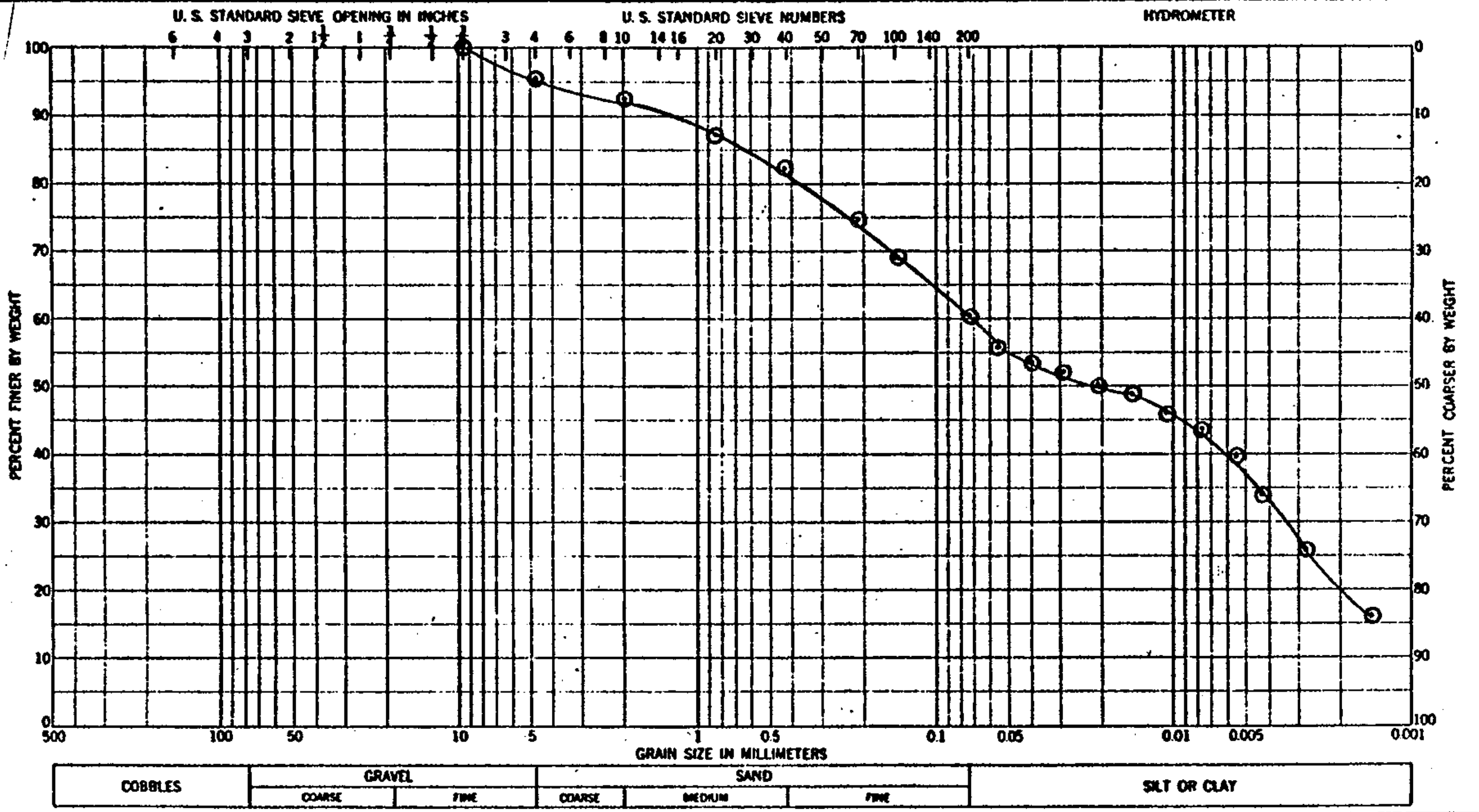
FORM 59(Test)

Boring No. FD-5

APPENDIX B

SOIL TEST RESULTS

Date of Testing - August 1981



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
J-9	20-22'	Gr.-sandy clay (CL) w/tr. of gravel	16.97	36	19	17
		Gr. 271				

Project East Boat Basin Cape Cod Canal

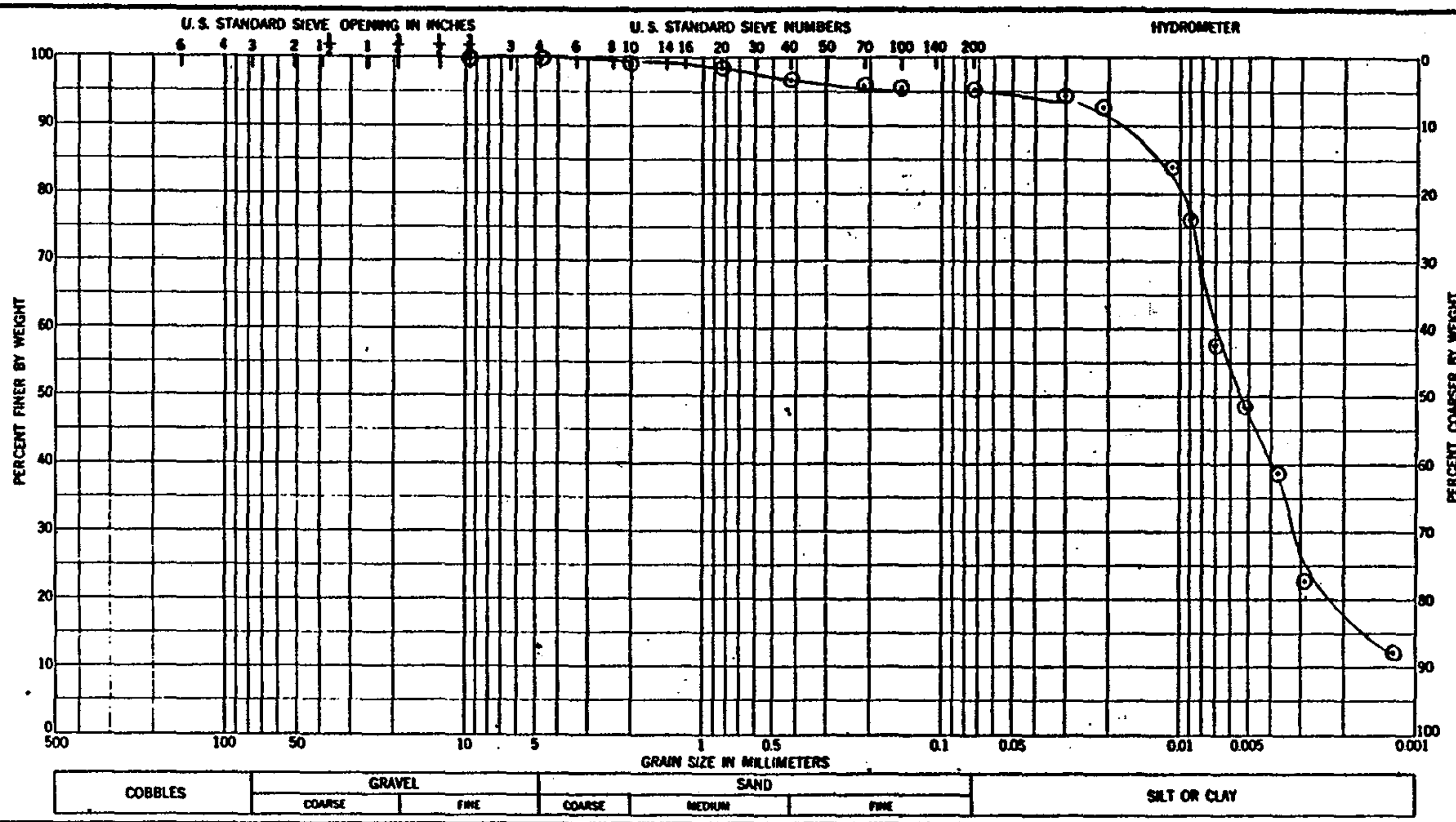
Area

Boring No. 4 FD-1

Date Aug. 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
5-9	30-32'	Gr.- loam silt (ML)	24.97	31	25	6
		Gr - 2.60				

Project East Boat Basin Cape Cod Canal

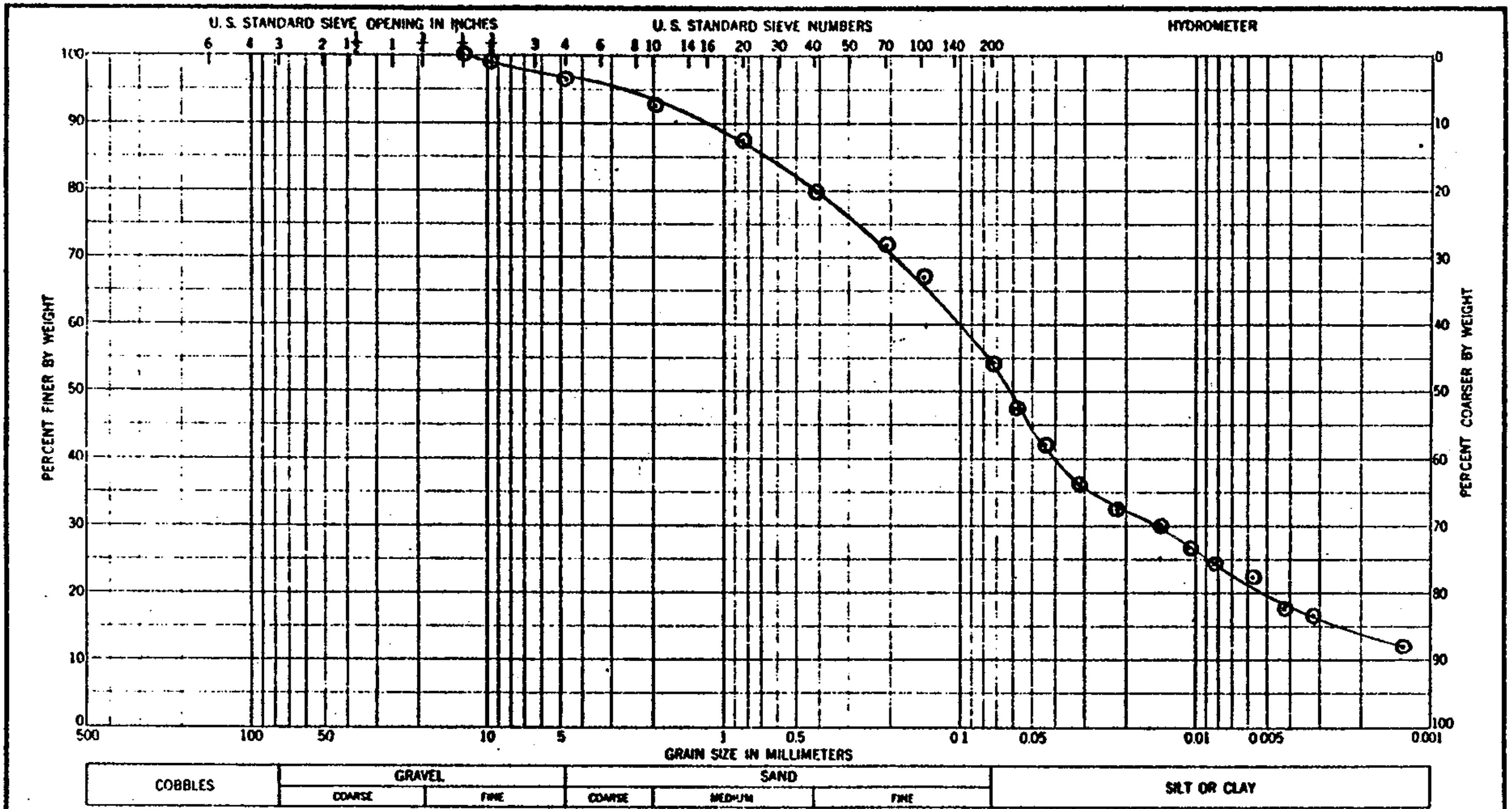
Area

Boring No. 5 FD-2

Date Aug 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
5-10	25-26.5'	Gr. sandy clay (CL) w/tr. of gravel Gr. C-59	14.52	28	16	12

Project East Boat Basin, Cape Cod Canal

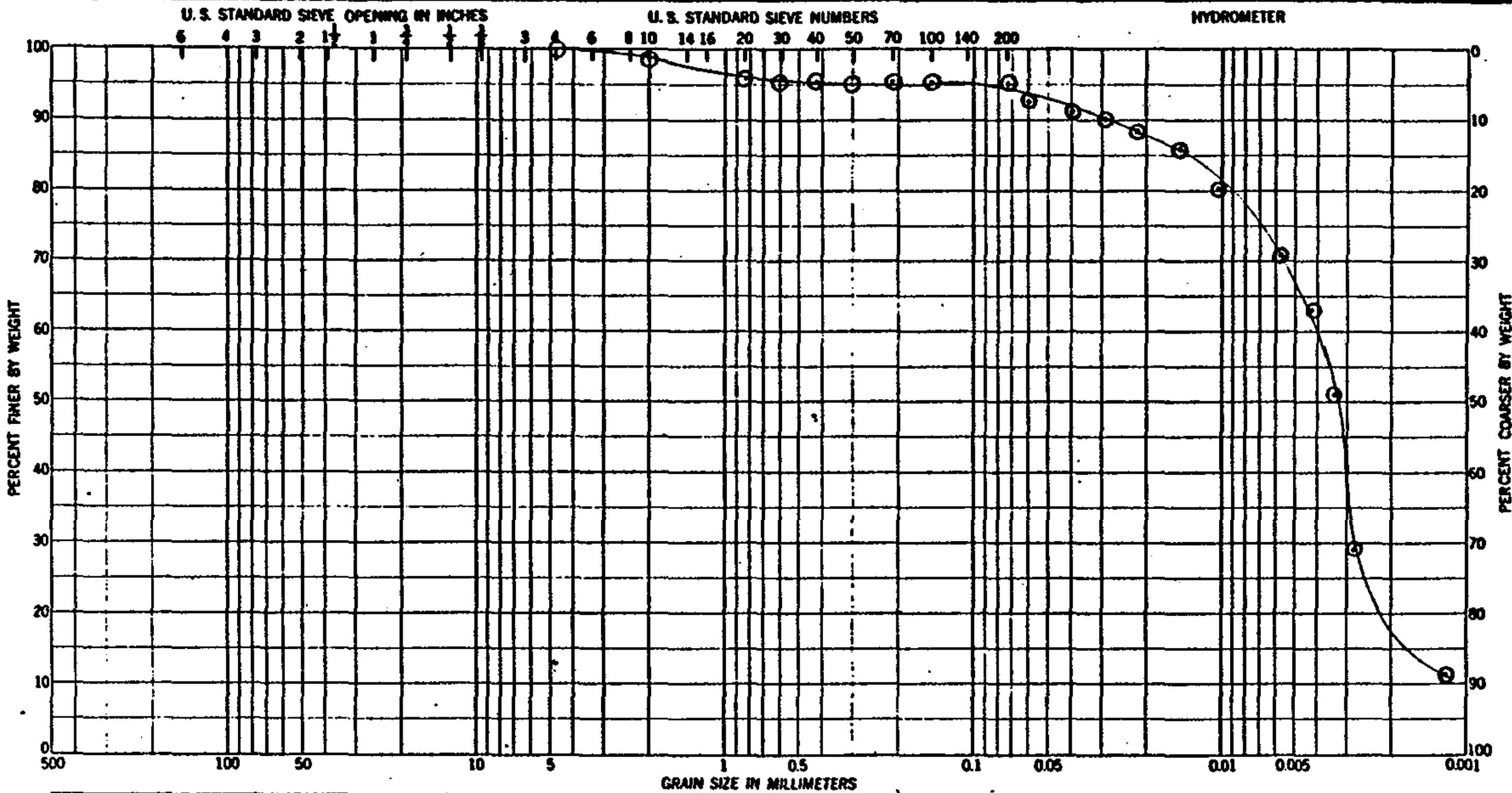
Area

Boring No. 4 FD-1

Date Aug 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087



<table>
<tr><td rowspan="2">COBBLES</td><td colspan="2">GRAVEL</td><td colspan="3">SAND</td><td rowspan="2">SILT OR CLAY</td></tr>
<tr><td>COARSE</td><td>FINE</td><td>COARSE</td><td>MEDIUM</td><td>FINE</td></tr>
</table>

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
S-11	31-32.5	Gr-lean silt (ML)	32.90	33	26	7
		Gr-2.67				

Project East Boat Basin Cape Cod Canal

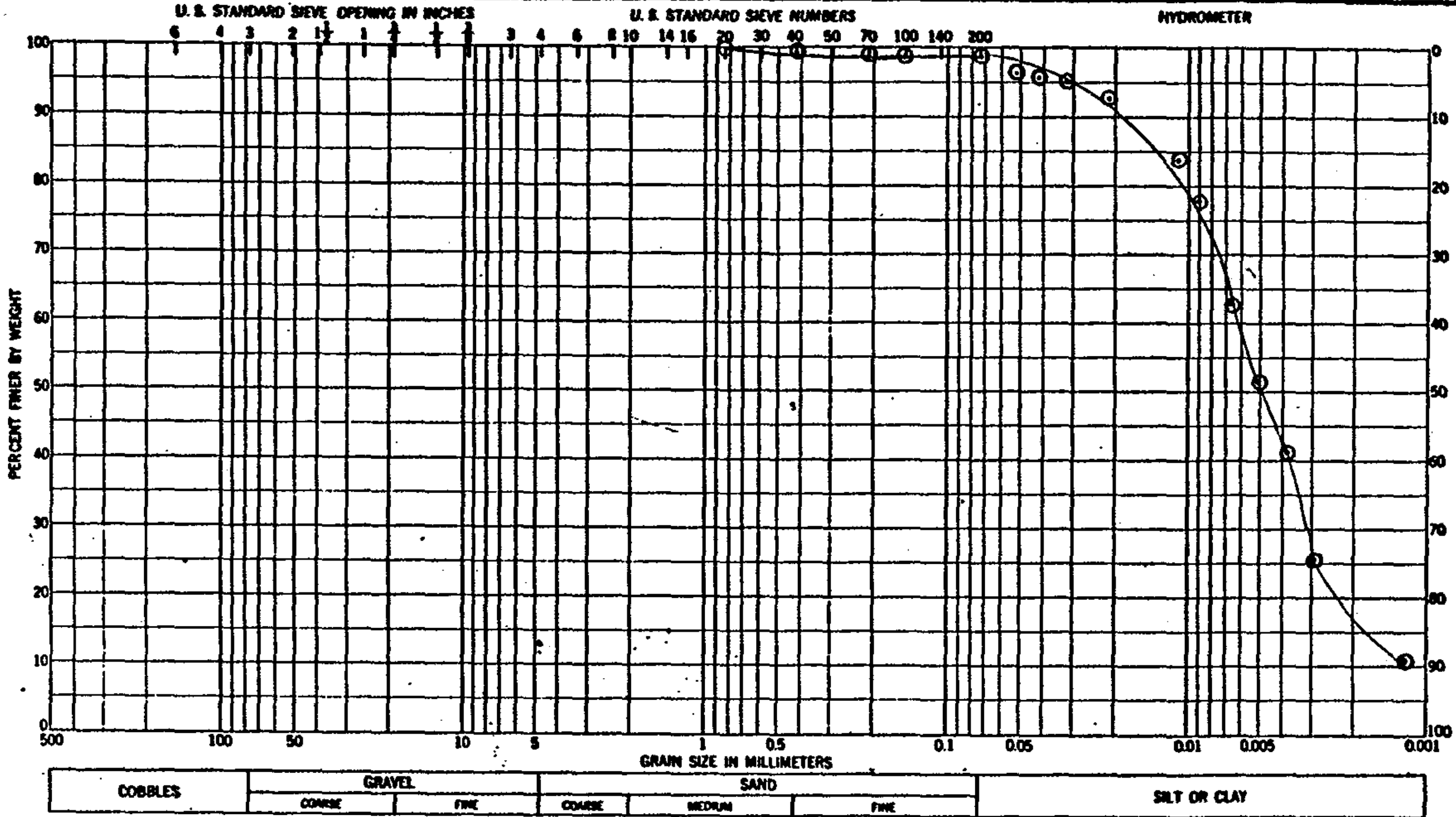
Area

Boring No. 4 FD-1

Date Aug 1981

GRADATION CURVES

ENG FORM 1 MAY 63 2087



Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
5-10	35-36.5'	Gr - lean silt (ML)	22.35	29	27	2
		Gr - 2.62				

Project: East Boat Basin, Cape Cod Canal

Area:

Boring No. 5 FD-2

Date: Aug 1981

GRADATION CURVES

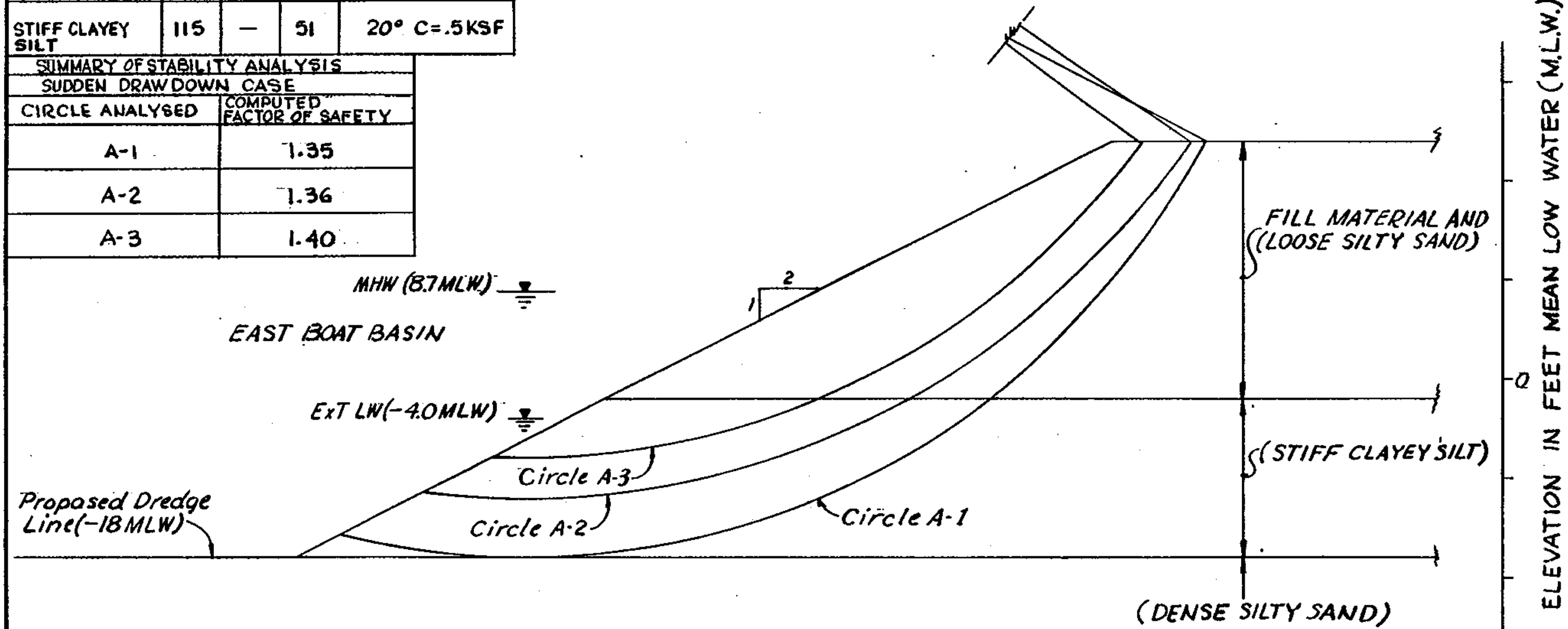
ENG FORM 1 MAY 63 2087

APPENDIX C

SUMMARY OF STABILITY ANALYSIS

ASSUMED DESIGN VALUES				
MATERIAL	UNIT WEIGHTS (PCF)			SHEAR STRENGTH
	γ_{SAT}	γ_{MOIST}	γ_{SUB}	ASSUMED R&S TEST DESIGN ENVELOPE VALUES
LOOSE SILTY SAND (FILL)	125	115	61	30° C=0
STIFF CLAYEY SILT	115	—	51	20° C=.5KSF

SUMMARY OF STABILITY ANALYSIS SUDDEN DRAWDOWN CASE	
CIRCLE ANALYSED	COMPUTED FACTOR OF SAFETY
A-1	1.35
A-2	1.36
A-3	1.40



TYPICAL SECTION

GRAPHIC SCALE

10' 0 10' 20'

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

EAST BOAT BASIN
SLOPE STABILITY ANALYSIS
SUDDEN DRAWDOWN CASE

DES.BY
DR.BY
CK.BY

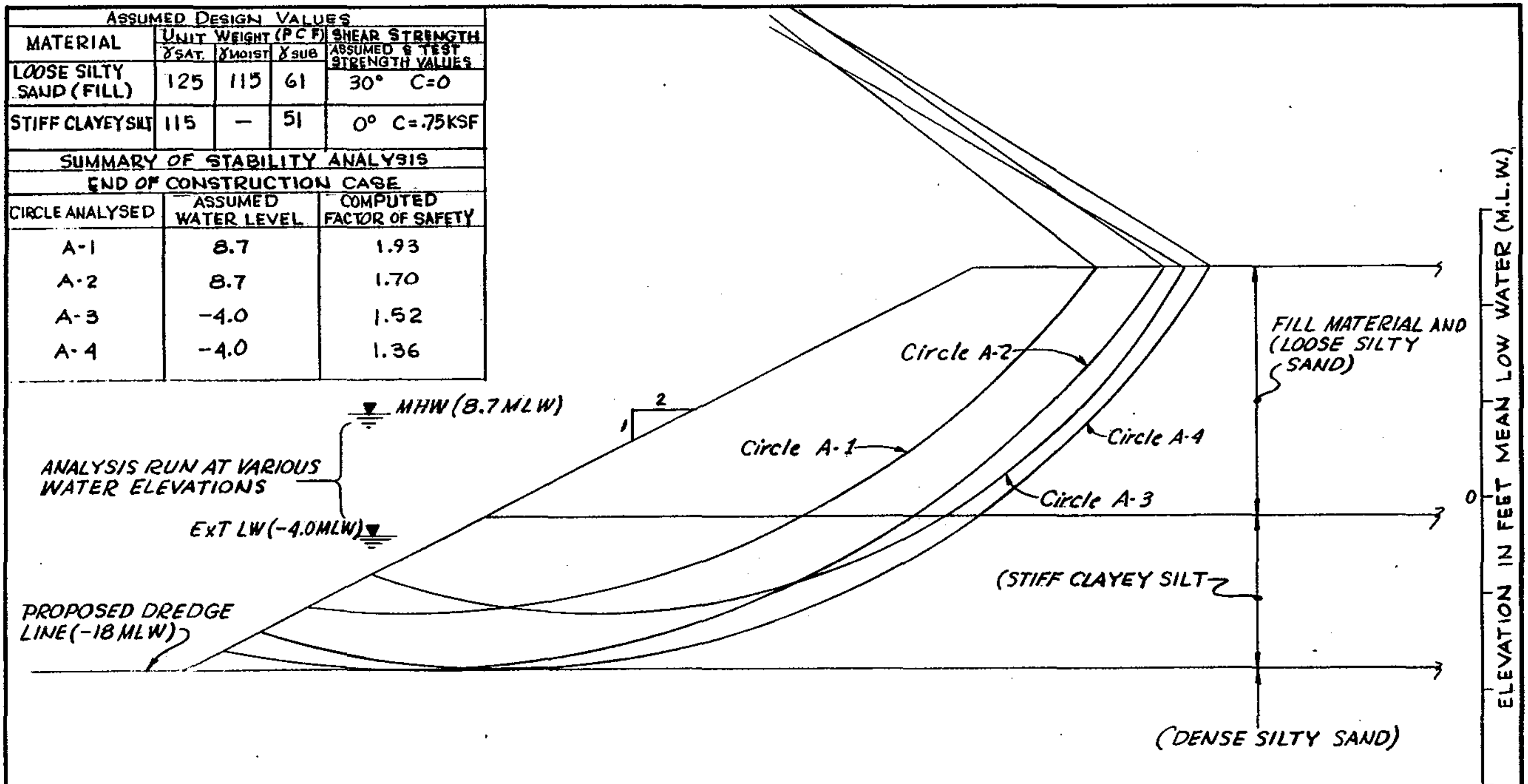
SANDWICH, MASS.

GEOTECH. ENG. BR. SCALE: 1" = 10'
SK. NO. DATE:

PLATE 2

ASSUMED DESIGN VALUES				
MATERIAL	UNIT WEIGHT (P C F)			SHEAR STRENGTH
	$\gamma_{SAT.}$	γ_{MOIST}	γ_{SUB}	ASSUMED & TEST STRENGTH VALUES
LOOSE SILTY SAND (FILL)	125	115	61	30° C=0
STIFF CLAYEY SILT	115	—	51	0° C=.75KSF

SUMMARY OF STABILITY ANALYSIS		
END OF CONSTRUCTION CASE		
CIRCLE ANALYSED	ASSUMED WATER LEVEL	COMPUTED FACTOR OF SAFETY
A-1	8.7	1.93
A-2	8.7	1.70
A-3	-4.0	1.52
A-4	-4.0	1.36



TYPICAL SECTION

GRAPHIC SCALE

10' 0 10' 20'

DEPARTMENT OF THE ARMY
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
WALTHAM, MASS.

EAST BOAT BASIN
SLOPE STABILITY ANALYSIS

END OF CONSTRUCTION CASE

SANDWICH, MASS.

DES. BY
DR. BY
CK. BY

GEOTECH. ENG. BR. SCALE: 1" = 10'
SK. NO. DATE:

APPENDIX D

BIBLIOGRAPHY

BIBLIOGRAPHY

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CAPE COD CANAL, SANDWICH, MA

December 1981

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MOORING/BERTHING FORMULAE

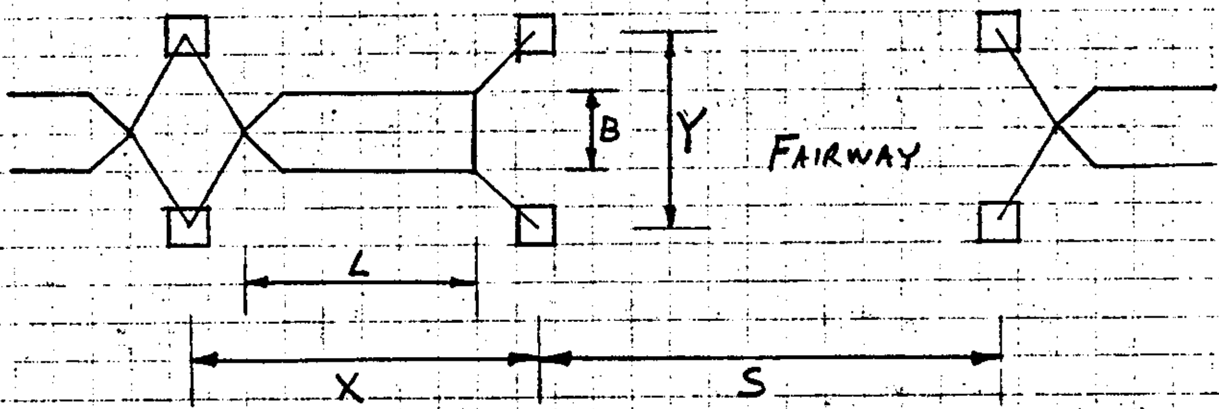
NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

PAGE 1

SUBJECT EAST BOAT BASIN NAVIGATION STUDY
COMPUTATION FOUR POINT OPEN MOORING ANALYSIS
COMPUTED BY D.Z. CHECKED BY DATE

TYPICAL FOUR POINT MOORING CONFIGURATION



B - VESSEL BEAM DIMENSION

L - VESSEL LENGTH DIMENSION

X - LENGTH OF MOORING AREA REQUIRED FOR ONE VESSEL

Y - WIDTH OF MOORING AREA REQUIRED FOR ONE VESSEL

S - WIDTH OF FAIRWAY

X = L + 30 FT FOR COMMERCIAL FISHING BOATS

X = L + 20 FT FOR RECREATIONAL BOATS

Y = B + 30 FT FOR COMMERCIAL FISHING BOATS

Y = B + 20 FT FOR RECREATIONAL BOATS

S = 2L FOR VESSELS OVER 40 FEET

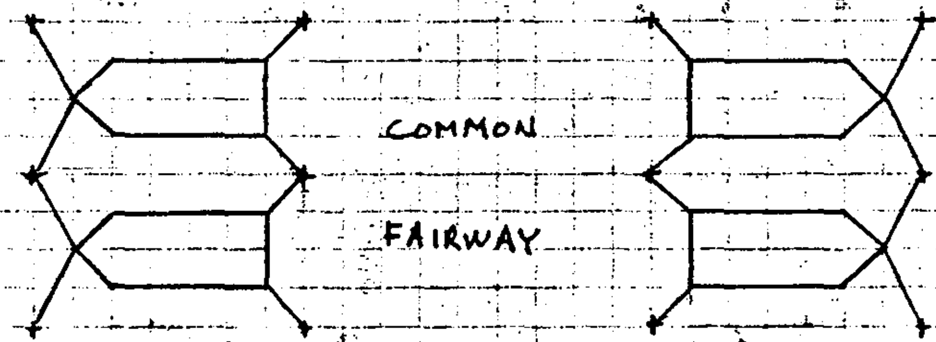
S = 1.75 L FOR VESSELS UNDER 40 FEET

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT East Boat Basin Navigation Study
COMPUTATION Four Point Open Mooring Analysis
COMPUTED BY D. Z. CHECKED BY DATE

A. Most Efficient Mooring Condition – Common Fairway



Area Computation For 1 Vessel (Refer To 1st Figure)

Commercial Fishing Vessels:

Over 40' $(X + S/2)Y$

$(L+30 + 2L/2)(B+30)$

$BL + 30B + BL + 30L + 900 + 30L$

$2BL + 30B + 60L + 900$

Under 40' $(X + S/2)Y$

$(L+30 + 1.75L/2)(B+30)$

$BL + 30B + .875BL + 30L + 900 + 26.25L$

$1.875BL + 30B + 56.25L + 900$

RECREATIONAL BOATS:

OVER 40' $(X + S/2)Y$

$(L + 20 + 2L/2)(B + 20)$

$BL + 20B + BL + 20L + 400 + 20L$

$2BL + 20B + 40L + 400$

UNDER 40' $(X + S/2)Y$

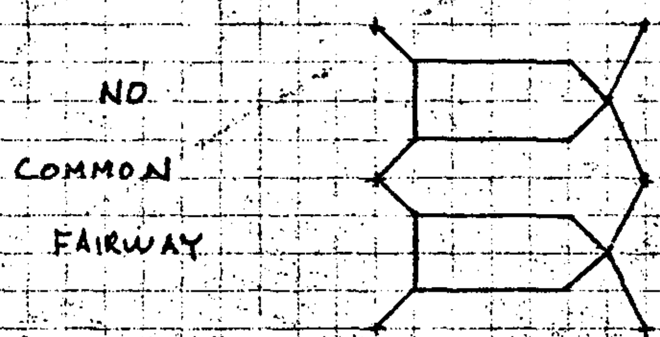
$(L + 20 + 1.75L/2)(B + 20)$

$BL + 20B + .875BL + 20L + 400 + 17.5L$

$1.875BL + 20B + 37.5L + 400$

B. <u>LEAST EFFICIENT MOORING CONDITION – NO COMMON FAIRWAY</u>

[illegible] USED



AREA COMPUTATION FOR 1 VESSEL (REFER TO 1ST FIGURE)

SUBJECT East Boat Basin Navigation Study
COMPUTATION Four Point Open Mooring Analysis
COMPUTED BY D.Z. CHECKED BY DATE

COMMERCIAL FISHING VESSELS:

OVER 40' $(X+S)Y$

$(L+30+2L)(B+30)$

$BL+30B+2BL+30L+900+60L$

$3BL+30B+90L+900$

UNDER 40' $(X+S)Y$

$(L+30+1.75L)(B+30)$

$BL+30B+1.75BL+30L+900+52.5L$

$2.75BL+30B+82.5L+900$

RECREATIONAL BOATS:

OVER 40' $(X+S)Y$

$(L+20+2L)(B+20)$

$BL+20B+2BL+20L+400+40L$

$3BL+20B+60L+400$

UNDER 40' $(X+S)Y$

$(L+20+1.75L)(B+20)$

$BL+20B+1.75BL+20L+400+35L$

$2.75BL+20B+55L+400$

SUBJECT EAST BOAT BASIN NAVIGATION STUDY
COMPUTATION FOUR POINT OPEN MOORING ANALYSIS
COMPUTED BY D.Z. CHECKED BY DATE

C. AVERAGE EFFICIENCY MOORING CONDITION

COMMERCIAL FISHING VESSELS:

OVER 40'

$$\frac{(2BL + 30B + 60L + 900) + (3BL + 30B + 90L + 900)}{2}$$

$$2.5BL + 30B + 75L + 900$$

UNDER 40'

$$\frac{(1.875BL + 30B + 56.25L + 900) + (2.75BL + 30B + 82.5L + 900)}{2}$$

$$2.31BL + 30B + 69.38L + 900$$

RECREATIONAL BOATS:

OVER 40'

$$\frac{(2BL + 20B + 40L + 400) + (3BL + 20B + 60L + 400)}{2}$$

$$2.5BL + 20B + 50L + 400$$

UNDER 40'

$$\frac{(1.875BL + 20B + 37.5L + 400) + (2.75BL + 20B + 55L + 400)}{2}$$

$$2.31BL + 20B + 46.25L + 400$$

D. PROCEDURE TO DETERMINE MOORING CAPACITY

THE DERIVED FORMULAS INCLUDE ALLOWANCE FOR FAIRWAYS

1. DETERMINE TYPICAL BOAT SIZE - LENGTH AND BEAM
2. SELECT APPROPRIATE FORMULA
3. DETERMINE AREA FOR 1 BOAT IN SQUARE FEET

SUBJECT EAST BOAT BASIN NAVIGATION STUDY
COMPUTATION FOUR POINT OPEN MOORING ANALYSIS
COMPUTED BY D.Z. CHECKED BY DATE

4. DIVIDE BY 43560 TO GET ACRES
5. TAKE RECIPROCAL FOR BOATS/ACRE

EXAMPLE: FISHING VESSEL, LENGTH 60', BEAM 18'

1. L = 60', B = 18'
2. ASSUME AVERAGE CONDITIONS, COMMERCIAL VESSEL > 40'
   $2.5\,BL + 30B + 75L + 900$
3. 8640 FT^2
4. .198 ACRES/BOAT
5. 5.04 BOATS/ACRE SAY 5 BOATS/ACRE

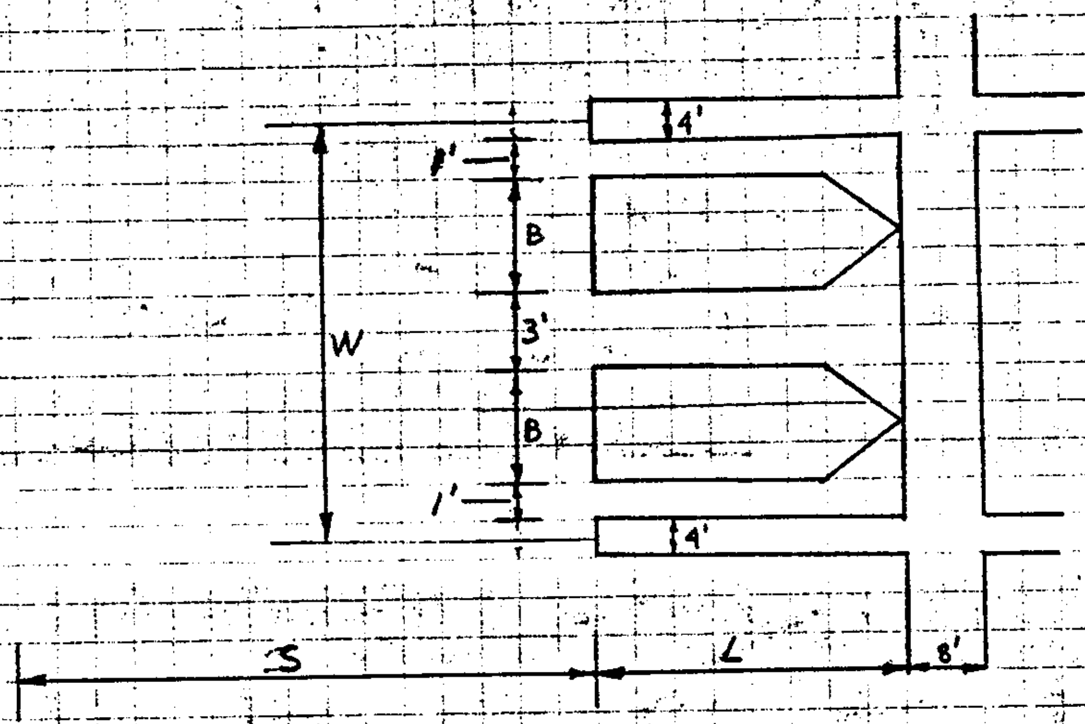
NED FORM 223 .
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U.S. ARMY

PAGE 1

SUBJECT EAST BOAT BASIN NAVIGATION STUDY
COMPUTATION SLIP BERTHING ANALYSIS
COMPUTED BY D.Z. CHECKED BY ______ DATE ______

TYPICAL SLIP BERTHING CONFIGURATION



B - VESSEL BEAM DIMENSION

L - VESSEL LENGTH DIMENSION

W - WIDTH OF BERTHING AREA (TWO BOATS)

S - WIDTH OF FAIRWAY

$W = 2B + 5 + 2(4/2) = 2B + 9$

$S = 2L$ FOR VESSELS OVER 40' FEET

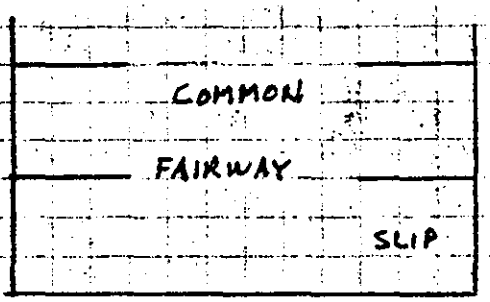
$S = 1.75\,L$ FOR VESSELS UNDER 40 FEET

NED FORM 223
27 Sept 49

NEW ENGLAND DIVISION
CORPS OF ENGINEERS, U. S. ARMY

SUBJECT East Boat Basin Navigation Study
COMPUTATION Slip Berthing Analysis
COMPUTED BY D.Z. CHECKED BY DATE

A. Most Efficient Slip Berthing Condition - Common Fairway



Area Computation For 2 Vessels (Refer To 1st Figure)

Over 40' $(\frac{1}{2}S + L + \frac{8}{2})W$

$[\frac{1}{2}(2L) + L + 4](2B+9)$

$(2L+4)(2B+9)$

$4BL + 18L + 8B + 36$

Under 40' $(\frac{1}{2}S + L + 4)W$

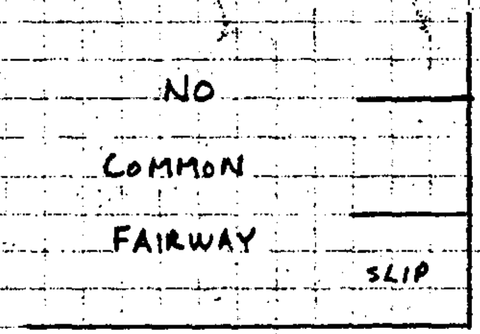
$[\frac{1}{2}(1.75L) + L + 4](2B+9)$

$(1.875L + 4)(2B+9)$

$3.75BL + 16.88L + 8B + 36$

SUBJECT: EAST BOAT BASIN NAVIGATION STUDY
COMPUTATION: SLIP BERTHING ANALYSIS
COMPUTED BY: D. Z. CHECKED BY: DATE:

B. LEAST EFFICIENT SLIP BERTHING CONDITION - NO COMMON FAIRWAY



AREA COMPUTATION FOR 2 VESSELS (REFER TO 1ST FIGURE)

OVER 40' $(S + L + 4)W$

$(2L + L + 4)(2B + 9)$

$(3L + 4)(2B + 9)$

$6BL + 27L + 8B + 36$

UNDER 40' $(S + L + 4)W$

$(1.75L + L + 4)(2B + 9)$

$(2.75L + 4)(2B + 9)$

$5.5BL + 24.75L + 8B + 36$

SUBJECT EAST BOAT BASIN NAVIGATION STUDY
COMPUTATION SLIP BERTHING ANALYSIS
COMPUTED BY D.Z. CHECKED BY ______ DATE ______

C. AVERAGE CASE (AREA FOR 2 BOATS)

OVER 40'

$$\frac{(4BL + 18L + 8B + 36) + (6BL + 27L + 8B + 36)}{2}$$

$$5BL + 22.5L + 8B + 36$$

UNDER 40'

$$\frac{(3.75BL + 16.88L + 8B + 36) + (5.5BL + 24.75L + 8B + 36)}{2}$$

$$4.63BL + 20.82L + 8B + 36$$

D. PROCEDURE TO DETERMINE BERTHING CAPACITY

THE DERIVED FORMULAS INCLUDE ALLOWANCE FOR FAIRWAYS

1. DETERMINE TYPICAL BOAT SIZE - LENGTH AND BEAM
2. SELECT APPROPRIATE FORMULA
3. DETERMINE AREA FOR 1 BOAT IN SQUARE FEET
4. DIVIDE BY 43560 TO GET ACRES
5. TAKE RECIPROCAL FOR BOATS/ACRE

EXAMPLE: FISHING VESSEL, LENGTH 60', BEAM 18'

1. L = 60', B = 18'
2. ASSUME AVERAGE CONDITIONS, $(5BL + 22.5L + 8B + 36)/2$
3. 3465 FT^2
4. .08 AC/BOAT
5. 12.57 BOATS/ACRE SAY 12 BOATS/ACRE

SECTION 2

ECONOMICS

ECONOMICS

Table of Contents

List of Tables

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ECONOMICS

This section of the supporting documentation contains the detailed analyses that were performed to determine the economic feasibility of alternative plans. Analyses of fleet projections, expansion area requirements, benefits, economic justification, and apportionment of project costs were performed.

FLEET PROJECTIONS - MAXIMUM CONDITION

Projections of future commercial fishing and recreational boating use of the expanded East Boat Basin were required to determine berthing area requirements and to establish project economic benefits. Projections were based on information obtained from the most knowledgeable public sources available. The information was used to project the maximum expected future activity that would occur at the East Boat Basin without configuration constraints.

COMMERCIAL FISHING FLEET PROJECTION

A number of fishery species were identified as having the potential to support additional harvesting at various levels in the future. Based on discussions with National Marine Fisheries Service, minimal increase in the traditional fishery is anticipated, while the non-traditional species, primarily surf clams and ocean quahogs, show the greatest potential for substantial growth. The number of vessels that would be supported by Sandwich's share of the future fishery was also estimated by NMFS. A reasonable growth assumption of 40 additional commercial vessels over a 10 year period was made. The composition of the fleet would then remain constant through the remainder of the project life. Table 2-1 summarizes the growth projection of the Sandwich based fleet.

Table 2-1

Projected Growth of the Sandwich Fleet

Type of	Present		Future		Growth	
Boat	Summer	Winter	Summer	Winter	Summer	Winter
Lobster	20	0	20	0	0	0
Trawler	18	29	58	69	40	40
Scallop	6	6	6	6	0	0
Total	44	35	84	75	40	40

It was assumed that 50 percent of the additional vessels would be transfer vessels from other ports. Transfer vessels would generally be of the workhorse 70-90 foot class fishing the traditional ground fishery. Transfer vessels would not adversely impact fishery resource levels since they would just be operating out of another port.

The remaining 50 percent of the additional vessels would be involved in new activity. The projected distribution of new boats is comprised of surf clam boats, groundfish boats and non-traditional fishery boats. Fishery parameters were projected for the new activities for use in performing economic analyses, and are contained in Table 2-2.

Table 2-2

Fishery Parameters - New Boats

Parameter	Surf Clam Boats	Groundfish Boats	Non-Traditional Boats
Length	50'-60'	50'-60'	75'-80'
Average Landing	3,000 lbs	4,000 lbs	75,000 lbs
Landing Frequency	1 per day	2 per week	1 per week
Operating Year	240 days	35 weeks	40 weeks

It is expected that up to 10 charter fishing boats could operate out of the East Boat Basin. Charter boats would typically be 40 to 50 feet in length, transporting up to 20 people for deep sea fishing. Charter boats are considered commercial vessels and would therefore be included as part of the commercial fishing fleet. Table 2-3 contains the projected distribution of additional vessels, yielding a total maximum future fleet of about 94 commercial vessels during the summer.

Table 2-3

Projected Commercial Vessel Increase - Maximum Condition

Vessel Type	Number	Percent	Average Size
Transfer	20	40	80'
Surf Clam	10	20	55'
Groundfish	5	10	55'
Non-Traditional	5	10	80'
Charter Fishing	10	20	50'
	50	100	

RECREATIONAL BOATING FLEET PROJECTION

Projections of future recreational boating use were made based an existing demand and the population growth for the area. The future fleet will be comprised of existing permanent boats, transient boats, immediate new permanent boats and future new permanent boats. It was assumed that the number of launchings from the existing boat ramp would not increase much, since many boats presently using the ramp would obtain storage space at the basin. This would offset increased use of the ramp in the future.

For purposes of comparing the without-project condition to the with-project condition, the without-project recreational fleet had to be determined. Since the without-project condition provides 60 additional slips (51 25-foot slips and 9 40-foot slips), additional boats can be added to the existing fleet. The current condition has 70 permanent boats in 60 slips, 12 transient boats in 12 slips and about 18 transient boats, on average, anchored in the basin. Under the without-project condition no anchoring of boats would take place, thereby requiring that 18 slips be made available to transients. Therefore slips were allocated to 18 transient boats first and then to boats on the waiting list, resulting in the without-project condition fleet shown on Table 2-4.

Table 2-4

Without-Project Condition Fleet

Boat Size	Existing Fleet	Waiting List	Slip Allocation 25-foot	Slip Allocation 40-foot	Without Project Fleet	Remaining Waiting List Boats
under 20'	19	44	0	0	19	44
21' to 24'	15	33	20	0	35	13
25' to 29'	10	22	22	0	32	0
30' to 35'	10	10	0	0	10	10
36' to 42'	9	3	0	0	9	3
43' to 50'	7	4	0	0	7	4
transients (25'+)						
slips	12	0	0	0	12	0
anchored	18	0	9	9	18	0
Total	100	116	51	9	142	74

A maximum possible future fleet projection was made to serve as an upper limit to benefits that could accrue to various plans, if slips were available. This maximum fleet projection was determined by summing the immediate fleet, and the number of future boats expected to saturate recreational boating in the area.

The maximum possible immediate fleet would be the existing 70 permanent boats, the 116 boats on the waiting list and 30 transients for a total of 216 boats (70+116+30). The saturation point for future fleet growth was determined by applying the projected population growth rate for Barnstable County, over the next 20 years to the immediate permanent fleet (70+116, transients not included). The projected population growth rate was used as a rough indicator for future fleet growth. It is estimated that the saturation point would approach about 300 permanent boats. With the number of transients assumed to remain constant at 30, the maximum possible future fleet projection would be about 330 boats.

With the project in place, it is believed that demand will equal supply in a shorter time period, roughly 10 years. Limited recreational boating opportunity and the recreational nature of the area should insure continued demand at the East Boat Basin into the future. Also, the experience of previously constructed projects has shown that demand accelerates when a project is in place. Therefore, future growth in the recreational fleet was assumed to occur over a 10 year period.

The following Table 2-5 displays the breakdown of the projected maximum future fleet.

Table 2-5

Breakdown of Projected Maximum Future Fleet

	Immediate permanent Fleet					
Boat Size	Existing Fleet	Waiting List	Total	Percent Breakdown	Future Growth	Future Fleet
under 20'	19	44	63	33.9	39	102
21' to 24'	15	33	48	25.8	29	77
25' to 29'	10	22	32	17.2	20	52
30' to 35'	10	10	20	10.7	12	32
36' to 42'	9	3	12	6.5	7	19
43' to 50'	7	4	11	5.9	7	18
Sub-total	70	116	186	100.0	114	300
Transients	30	0				30
Total	100	116			114	330

EXPANSION AREA REQUIREMENTS

As part of the formulation process, the amount of expansion area necessary to accommodate the anticipated future maximum activity was determined. In addition to the area needed to store the commercial fishing and recreational boating fleets, area required for maneuvering, offloading and an entrance channel were considered. Area requirements for both slip berthing and open mooring were analyzed for comparison in economic analyses.

COMMERCIAL FLEET AREA REQUIREMENTS

Berthing and open mooring areas were determined by using the boat storage formulas developed in the Engineering section of the Supporting Documentation. The average case formulas were used to determine the area required per boat. Area requirements were determined by calculating the expected new vessel size and then applying the aforementioned formulas. Expected vessel size was calculated using average lengths from Table 2-3. Beam dimensions were taken from Figure 1-2 of the Navigation System Design section.

Expected size of new vessel:

$$E \text{ (new vessel)} = .4\ (80) + .2\ (55) + .1\ (55) + .1\ (80) + .2\ (50)$$
$$= 32 + 11 + 5.5 + 8 + 10$$
$$= 66.5 \text{ feet long - Say 67 feet}$$

Slip berthing area required: L = 67 feet, B = 20 feet

$(5BL + 22.5L + 8B + 36)\ /2 = 4202\ ft^2/boat = .096$ acres/boat

50 boats x .096 acres/boat = 4.8 acres

Open mooring area required: L = 67 feet, B = 20 feet

$2.5BL + 30B + 75L + 900 = 9875\ ft^2/boat = .227$ acres/boat

50 boats x .227 acres/boat = 11.4 acres

RECREATIONAL FLEET AREA REQUIREMENTS

Berthing and mooring area requirements for the recreational fleet were determined in the same manner as for the commercial fishing fleet. The remaining boats on the waiting list were added to future growth boats, resulting in the number of boats requiring space. Table 2-6 provides the number and sizes of boats needing storage space. Beam dimensions for recreational boats were determined by averaging interpolated beam values of power boats and sailboats given on Figure 2-1.

TYPICAL RECREATIONAL BOAT DIMENSIONS

TYPES AND SIZES OF TYPICAL POWERBOATS

LOA = LENGTH OVERALL   B = BEAM   HOA = HEIGHT OVERALL   D = DRAFT

CLASSIFICATION	AND NAME	LENGTH OVERALL	BEAM	HEIGHT OVERALL	DRAFT	WEIGHT (LBS)
RUNABOUT	SEA ROCKET	9'– 8"	4'– 8"	1'– 9"	0'– 4"	210
	MONARCH 1230	12'– 0"	3'– 9"	1'– 2"	0'– 3"	80
	PIRANNA I	14'– 0"	5'– 6"	2'– 4"	0'– 6"	375
	OPEN FISHERMAN	19'– 8"	7'– 6"	4'– 5"	0'– 11"	1200
SEDAN	CAPRICE 197	18'– 2"	7'– 5"	3'– 5"	0'– 10"	2400
	NORSEMAN 19	19'– 0"	7'– 4"	4'– 1"	1'– 3"	1560
	COMMODORE 486	23'– 0"	8'– 0"	5'– 0"	1'– 0"	2970
	SEAMASTER 27	26'– 9"	9'– 10"	9'– 0"	1'– 8"	7200
CRUISER	EXPRESS CRUISER	28'– 3"	10'– 10"	10'– 10"	–	6000
	CONSTELLATION	36'– 0"	12'– 0"	12'– 7"	2'– 8"	14870
	38' MOTOR YACHT	37'– 10"	14'– 2"	11'– 6"	2'– 6"	22400
	SEA VOYAGER	42'– 5"	14'– 10"	11'– 0"	3'– 2"	25000
HOUSE-BOAT	GYPSY	20'– 1"	7'– 11"	7'– 4"	0'– 9"	2000
	CRIS-CRAFT 33	33'– 3"	12'– 0"	12'– 11"	2'– 5"	10000
	RIVER QUEEN 40	40'– 0"	12'– 0"	10'– 6"	2'– 0"	16000
	SPORTSMAN	50'– 0"	12'– 6"	10'– 0"	0'– 10"	19000

TYPES AND SIZES OF TYPICAL SAILBOATS   LOA = LENGTH OVERALL, B = BEAM, MH = MAST HEIGHT, D = DRAFT

CLASSIFICATION	AND NAME	LENGTH OVERALL	BEAM	MAST HEIGHT	DRAFT	WEIGHT (LBS.)
SMALL SAILBOAT	SEVEN ELEVEN	7'–11"	4'–2"	13'–0"	0'–4"	89
	ROOSTER	9'–7"	3'–10"	8'–0"	0'–5"	100
	SPRITE	10'–2"	4'–9"	15'–10"	0'–3"	150
	SUNFISH	13'–9"	4'–0"	9'–1 1/2	0'–4"	139
DAY SAILER	WINDMILL	15'–6"	4'–8"	17'–10"	0'–6"	198
	HIGHLANDER	20'–0"	6'–8"	27'–0"	0'–8"	830
	Y-FLYER	18'–2"	5'–9"	23'–0"	0'–6"	500
	LIGHTNING	19'–0"	6'–6"	26'–0"	0'–6"	700
CRUISING SAILBOAT	FIREBIRD	19'–5"	6'–7"	23'–8"	1'–4"	1,060
	CAL 25	25'–0"	8'–0"	29'–9"	4'–0"	4,000
	PRIVATEER	31'–3"	8'–0"	31'–6"	3'–6"	6,340
	ISLANDER 55	54'–8"	14'–0"	53'–0"	5'–9"	38,000

FIGURE 2-1

Table 2-6

Recreational Boats Requiring Space

Boat Size	Average Size	Waiting List	Future Growth	Total New Boats	Percent
under 20'	20'	44	39	83	44.2
21' to 24'	22.5'	13	29	42	22.3
25' to 30'	27.5'	0	20	20	10.6
31' to 35'	33'	10	12	22	11.7
36' to 42'	39.5'	3	7	10	5.3
43' to 50'	46.5'	4	7	11	5.6
Total		74	114	188	100.0

Expected size of new boats:

E (new boats) = .442 (20) + .223 (22.5) + .106 (27.5) + .117

(33)

+ .053 (39.5) + .059 (46.5) = 25.47 feet - Say 26 feet

Slip berthing area required: L = 26 feet, B = 9 feet

(4.63BL + 20.82L + 8B + 36) /2 = 867 ft^2/boat = .020 acres/boat

188 boats x .020 acres/boat = 3.8 acres

Open mooring area required: L = 26 feet, B = 9 feet

$$2.31BL + 20B + 46.25L + 400 = 2323\ ft^2/boat = .053\ acres/boat$$

188 boats x .053 acres/boat = 10.0 acres

CHANNEL AND MANEUVERING AREA REQUIREMENTS

Various areas along the interior of the expanded basin are expected to have fish offloading and other marine related development along them. Therefore, access via on entrance channel and turning/maneuvering areas will be necessary. The exact amount of area required will be dependent on the specific alternative plans. Based on the town's study and as borne out by the formulation of plans, the required area ranged from about 2.5 acres to 3.5 acres. An average of 3.0 acres was assumed as the area needed for the entrance channel and maneuvering areas.

AREA REQUIREMENTS - CONCLUSIONS

The expansion areas required to accommodate the maximum projected condition are summarized in Table 2-7 for both slip berthing and open mooring. The figures indicate the necessary water surface area only.

Table 2-7

Maximum Projected Condition - Area Requirements

Area	Slip Berthing	Open Mooring
Commercial area	4.8 acres	11.4 acres
Recreational area	3.8 acres	10.0 acres
Channel, maneuvering area	3.0 acres	3.0 acres
Total	11.6 acres	24.4 acres

FLEET PROJECTIONS - ALTERNATIVE PLANS

Commercial fishing and recreational boating fleets were projected for each detailed plan based on plan implementation impacts, and the amount of expansion berthing area available. Implementation impacts will cause the relocation of existing boats and affect the overall make-up of the fleets. The projections were made using the boat storage formulas previously derived, for both the slip berthing and open mooring conditions.

COMMERCIAL FLEET PROJECTIONS

Under the proposed harbor management measures, the entrance channel would separate the commercial activities on the east from recreational activities on the west. The size of area then available for commercial vessels in the existing basin would be as listed below.

Plan A - 2.7 acres

Plan B - 2.7 acres

Plan C - 2.7 acres

Plan D - 1.8 acres

The existing commercial fleet was first allocated to the existing basin area, and any remaining vessels were allocated to the commercial expansion berthing area. It was assumed that slips would be used in the existing basin for all cases, since without-project condition slips would continue to be used. The space requirement for the existing fleet was based on the average vessel and size of fleet for the summer condition. Table 2-8 shows the fleet breakdown, including Coast Guard and Corps of Engineers vessels which would also retain berthing space.

Table 2-8

Existing Commercial Fleet - Summer Condition

Vessel Type	Number	Percent of Fleet	Average Size
Lobster	20	43	30'
Trawler	18	38	50'
Scallop	6	13	50'
Coast Guard	2	4	45'
Corps of Engineers	1	2	80'
Total	47	100	

Average size of existing vessels:

Average length = .43 (30) + .38 (50) + .13 (50) + .04 (45) + .02 (80) = 41.8 feet - Say 42 feet

Beam (from graph) = 14 feet

Area required per existing vessel:

$[5 (14) (42) + 22.5 (42) + 8 (14) + 36] /2 = 2016 \text{ ft}^2$ - .046 acres

Total area required for existing fleet:

.046 ac/vessel x 47 vessels = 2.2 acres

Plans A, B and C would provide sufficient space to berth the entire existing fleet in the existing basin. Plan D would be able to berth only 39 vessels (1.8 acres ÷ .046 ac/vessel) because of the channel alignment, and would therefore allocate the remaining 8 existing vessels to the expansion area. Given the available commercial berthing area of the expansion for each plan and the expected new vessel size, the fleet increase for each plan was projected. Expansion commercial berthing area available for each plan would be 3.3 acres for Plan A, 4.3 acres for Plan B, 4.5 acres for Plan C and 4.6 acres for Plan D. Prior to projecting fleet sizes the net available commercial expansion berthing area was determined for all plans. Plan D would have a net loss in berthing area for new boats as detailed below.

Plan D: Net commercial berthing area.

Eight existing vessels, average size L = 42 feet and B = 14 feet to be located in the expansion berthing area.

If expansion berthing area is open mooring:

$$\begin{aligned}\text{Area per boat} &= 2.5BL + 30B + 75L + 900 \\ &= 2.5\ (14)\ (42) + 30\ (14) + 75\ (42) + 900 \\ &= .136 \text{ acres}\end{aligned}$$

Acres required = 8 boats x .136 acres/boat = 1.1 acres

Net area (open mooring) = 4.6 - 1.1 = 3.5 acres

If expansion berthing is slip berthing:

Area per boat = .046 acres

Area required = 8 boats x .046 acres/boat = .4 acres

Net area (slip berthing) = 4.6 - .4 = 4.2 acres

Also Plans A, B and C would have .5 acres of existing basin space available for berthing of new commercial fishing vessels. Their net area available for additional vessels would total 3.8 acres, 4.8 acres and 5.0 acres, respectively.

The future fleet increases were projected by dividing the available commercial berthing area by the area required for each vessel, as calculated in the Expansion Area Requirements section. Fleet projections were determined in Table 2-9 below for slip berthing and open mooring.

Table 2-9

Projected Fleet Increase

		Area Per Vessel*		Total Fleet Increase	
Plan	Area	Slip Berthing	Open Mooring	Slip Berthing	Open Mooring
A	3.8 ac	.096 ac	.227 ac	40	17
B	4.8 ac	.096 ac	.227 ac	50	21
C	5.0 ac	.096 ac	.227 ac	52	22
D	4.2 ac/3.5 ac	.096 ac	.227 ac	44	15

*Figures from Expansion Area Requirements section.

The projected fleet increases were then distributed according to the percentages of the projected maximum condition to determine the fleet make-up. The following Table 2-10 presents the breakdown of projected fleet increases for each plan.

Table 2-10

Breakdown of Projected Fleet Increases

Slip Berthing

Vessel Type	Percent	A	B	C	D
Transfer	40	16	20	21	18
Surf Clam	20	8	10	11	9
Groundfish	10	4	5	5	4
Non-Traditional	10	4	5	5	4
Charter Fishing	20	8	10	10	9
Total	100	40	50	52	44

Open Mooring

Vessel Type	Percent	A	B	C	D
Transfer	40	7	8	9	6
Surf Clam	20	3	5	5	3
Groundfish	10	2	2	2	2
Non-Traditional	10	2	2	2	1
Charter	20	3	4	4	3
Total	100	17	21	22	15

RECREATIONAL FLEET PROJECTIONS

The development of recreational fleet projections required that several plan implementation impacts and proposed harbor management measures be considered, since they would affect the make-up of project fleets. The considerations and their impact on the without-project recreational fleet are discussed below.

1. Entrance Channel Impacts - Construction of an entrance channel through the existing basin would take up more area than under the without-project condition, due to the need for a larger channel. The existing recreational and commercial berthing areas would lose some berthing capacity.

2. Separation of Navigation Activities Impacts - An objective of the project would be to keep recreational and commercial activities separate. Under this harbor management measure commercial vessels would be located on the east side of the basin and recreational boats on the west side. Due to the channel alignment, there would be sufficient berthing area for the entire existing commercial fleet on the east. However, the recreational fleet will realize a further loss of berthing space as a result of the separation of activities. About 40 boats, 25 feet in length would be displaced from the east side, of which 24 boats would be moved to space vacated by commercial boats on the west. The net displacement due to the entrance channel and separation of activities would be 16 boats for Plans A, B and C. The net displacement for Plan D would be 13 boats, since the

channel alignment will allow placement of at least 3 more boats on the west side of the existing basin.

3. Basin Expansion Impacts - Expansion of the basin would displace additional recreational boats that are located at the back of the basin. About 24 boats 30 to 50 feet in length would be displaced. Table 2-11 summarizes the number of boats displaced by each project component for each plan.

Table 2-11

Recreational Boats Displaced By Expansion Project

	Boats Displaced By			
Plans	Commercial Expansion	Recreational Expansion	Entrance Channel	Total Displaced
A	8	10	6	24
B	8	10	6	24
C	8	10	6	24
D	0	16	8	24

Therefore, the total number of boats displaced by all impacts is given in Table 2-12. These boats would have to obtain berthing space in the expansion area.

Table 2-12

Total Recreational Boats Displaced

	Displaced by		
Plan	Entrance Channel and Separation[1]	Basin Expansion[2]	Total
A	16	24	40
B	16	24	40
C	16	24	40
D	13	24	37

1. Boats 25 feet in length.
2. Boats 30-50 feet in length.

The number of recreational boats remaining in the existing basin would be 102 for Plans A, B and C, and 105 for Plan D. The make-up of the remaining boats is contained in Table 2-13.

Table 2-13

Remaining Existing Basin Fleet

Size	Without Project Fleet	Displaced Boats	Total Remaining
under 20'	19	-	19
21' to 24'	35	-	35
25' to 29'	32	16 (13)[1]	16 (19)[1]
30' to 35'	25[2]	-	25
36' to 42'	24[2]	17	7
43' to 50'	7	7	
TOTAL	142	40 (37)[1]	102 (105)[1]

1. ( ) indicates Plan D.
2. The 30 transient boat-equivalents were broken out between these two boat categories on a 50/50 basis for simplification of discussion and is carried into further analyses.

4. Rack Storage Impacts - The town of Sandwich wishes to incorporate rack storage of recreational boats into a basin expansion plan. It was assumed that a rack storage facility for 120 boats to 25 feet in length would be provided, based on the town's study. It was assumed that the remaining

without-project condition boats would remain in place along the western portion of the basin. Therefore, any growth in the recreational fleet would be placed in the expansion area and the rack storage facility. Projected growth in permanent recreational boats is contained in Table 2-14 below.

Table 2-14

Projected Growth - Recreational Boats

Size	Immediate Growth[1]	10-year Growth[2]	Total Growth
under 20'	44	39	83
21' to 24'	13	29	42
25' to 29'	0	20	20
30' to 35'	10	12	22
36' to 42'	3	7	10
43' to 50'	4	7	11
Total	74	114	188

1. See Table 2-4, last column.

2. See Table 2-5, second to last column.

The total growth of 188 boats would be allocated between the rack storage facility and the expansion berthing area. From Table 2-14, 83 boats under 20' and 37 boats 21' to 24' would be allocated to the rack storage facility, for a total of 120 boats. Therefore, only the remaining 68 new growth boats would be allocated to the expansion berthing area.

The total number of boats that would be allocated to the expansion berthing area would be the sum of displaced boats and the 68 growth boats. The displaced boats would be allocated first and any remaining space would be given to growth boats. Tables 2-15 and 2-16 contain the breakdowns of displaced boats and growth boats.

Table 2-15

Breakdown of Displaced Boats

Size	Average Size	Number	% of Total
25' to 29'	27.5'	16 (13)[1]	40 (35.1)[1]
30' to 35'	33'	0	0 (0)[1]
36' to 43'	39.5'	17	42.5 (46.0)[1]
43' to 50'	46.5'	7	17.5 (18.9)[1]
Total		40 (37)[1]	100.0

1. ( ) indicates Plan D.

Table 2-16

Breakdown of Growth Boats

		Growth				
	Average	Immediate		10-Year		
Size	Size	Number	%	Number	%	Total
21' to 24'	22.5'	0	0	5	9.8	5
25' to 29'	27.5'	0	0	20	39.2	20
30' to 35'	33'	10	58.8	12	23.6	22
36' to 42'	39.5'	3	17.7	7	13.7	10
43' to 50'	46.5'	4	23.5	7	13.7	11
Total		17	100	51	100.0	68

Average size of displaced boat: L = 37 feet, B = 12 feet

Average size = .351 (27.5) + .46 (39.5) + .189 (46.5)

= 36.6 feet - Say 37 feet

Average size of growth boat: L = 34 feet, B = 11 feet

Average size = .074 (22.5) + .294 (27.5) + .323 (33) + .147 (39.5) + .162 (46.5)

= 33.7 feet - Say 34 feet

Area required per boat: Displaced Boats

Slip Berthing

[4.63 (12) (37) + 20.82 (37) + 8 (12) + 36] /2 = .034 acres

Open Mooring

[2.31 (12) (37) + 20 (12) + 46.25 (37) + 400] = .078 acres

Area required per boat: Growth Boats

Slip Berthing

[4.63(11)(34) + 20.82 (34) + 88 + 36]/2 = 0.29 acres

Open Mooring

[2.31(11)(34) + 20 (11) + 46.25 (34) + 400] = 0.70 acres

The previous equations determined the average area required for each displaced boat and growth boat, for both the open mooring and slip berthing conditions. Since displaced boats would receive space first, the total area taken up by displaced boats for each plan was determined. The remaining expansion area would then be available for growth boats. Table 2-17 below summarizes these steps.

Table 2-17

Area Remaining for Growth Boats

Plan	Available Area (ac)	Displaced Boat Area (ac) Open Mooring	Displaced Boat Area (ac) Slip Berthing	Area Remaining (ac) Open Mooring	Area Remaining (ac) Slip Berthing
A	1.4	3.12	1.36	-(18)*	.04
B	2.3	3.12	1.36	-(29)*	.94
C	1.8	3.12	1.36	-(23)*	.44
D	2.8	2.89	1.26	-(36)*	1.54

*The numbers in parenthesis indicate the number of boats of the 40 displaced boats that could be accommodated.

From Table 2-17 it can be seen that the open mooring condition would not provide sufficient space for growth of the wet storage fleet. In fact, not even all of the displaced boats could be provided with space.

Therefore, open-mooring of recreational boats was not considered effective and only the slip berthing configuration was evaluated. Based on the area requirement formulas for growth boats, the total number of boats that could be placed in the expansion area using slips was determined in Table 2-18 below.

Table 2-18

Recreational Fleet - Expansion Area

Plan	Displaced Boats	Area Remaining[1]	Growth Boats[2]	Total Boats
A	40	.04 acres	1	41
B	40	.94 acres	32	72
C	40	.44 acres	15	55
D	37	1.54 acres	53	90

[1]From Table 2-17, last column.

[2]The remaining area was divided by the .029 ac/boat factor from p. 2-27 to obtain number of growth boats.

Immediate growth boats were allocated to the expansion area first, and then 10-year growth boats were allocated to any remaining space. In instances where all boats could not be accommodated, boats were equally distributed by the percentages contained in Table 2-16 to the respective growth category.

The fleet projections showing the total breakdown for each plan are summarized in Table 2-19, and include existing basin boats, rack storage growth boats, displaced boats and expansion area growth boats.

Table 2-19

Projected Recreational Fleets

Size	Existing Basin Boats	Rack Storage Boats Immediate	Rack Storage Boats 10-year	Expansion Area Boats Displaced	Expansion Area Boats New Boats Immediate	Expansion Area Boats New Boats 10-year	Total
Plan A							
under 20'	19	44	39	0	0	0	102
21' to 24'	35	13	24	0	0	0	72
25' to 29'	16	0	0	16	0	0	32
30' to 35'	25	0	0	0	1	0	26
36' to 42'	7	0	0	17	0	0	24
43' to 50'	0	0	0	7	0	0	7
Total	102	57	63	40	1	0	263
Plan B							
under 20'	19	44	39	0	0	0	102
21' to 24'	35	13	24	0	0	1	73
25' to 29'	16	0	0	16	0	6	38
30' to 35'	25	0	0	0	10	4	39
36' to 42'	7	0	0	17	3	2	29
43' to 50'	0	0	0	7	4	2	13
Total	102	57	63	40	17	15	294
Plan C							
under 20'	19	44	39	0	0	0	102
21' to 24'	35	13	24	0	0	0	72
25' to 29'	16	0	0	16	0	0	32
30' to 35'	25	0	0	0	9	0	34
36' to 42'	7	0	0	17	3	0	28
43' to 50'	0	0	0	7	3	0	10
Total	102	57	63	40	15	0	278
Plan D							
under 20'	19	44	39	0	0	0	102
21' to 24'	35	13	24	0	0	4	76
25' to 29'	19	0	0	13	0	14	46
30' to 35'	25	0	0	0	10	8	43
36' to 42'	7	0	0	17	3	5	32
43' to 50'	0	0	0	7	4	5	16
Total	105	57	63	37	17	36	315

BENEFIT ANALYSIS

EXISTING PROJECT

The East Boat Basin along the Cape Cod Canal is the only deepwater harbor in Sandwich. Old Harbor at Sandwich Glass Works is too small and shoal for any kind of commercial activity except for a small skiff operation. The East Boat Basin currently serves multiple functions. It was originally established as a harbor of refuge by the Corps of Engineers and includes a town-owned marina for recreational craft, a public launch ramp, berthing for a very limited number of commercial fishing vessels, and berthing for the U.S. Coast Guard and Corps of Engineers' vessels. The land areas adjacent to the harbor are heavily commercialized and are zoned for industry and marine use. On each side of the entrance to the basin are bulkheads owned and maintained by the U.S. Army Corps of Engineers. Fish off-loading areas exist outside of the harbor in the Cape Cod Canal along the Corps of Engineers' bulkhead. Several fish dealers are located on the canal; most of these dealers lease their property from the Corps. The Corps also maintains recreation areas on the both sides of the basin, including parking areas, picnic areas, and comfort stations.

BENEFITS

Benefits associated with the proposed expansion of the East Boat Basin are determined and discussed relative to the value of commercial fishing and recreational boating, including charter boat fishing. The evaluation is performed with an accuracy and precision consistent with the basic data and appropriate to the stage of study. The following paragraphs contain a discussion of these benefits. Where possible, estimates have been provided by knowledgeable local sources. In some cases, however, best estimates are made because local interests were unable to provide adequate data.

COMMERCIAL FISHING - WITHOUT PROJECT CONDITION

According to the Cape Cod Planning and Economic Development Commission, the East Boat Basin is the second largest port on Cape Cod in terms of catch. Only Provincetown exceeds Sandwich in pounds of fish landed and dollar values of the catch. In 1980 Sandwich ranked fifth in landings among Massachusetts ports, below the ports of Gloucester, New Bedford, Boston and Provincetown. As shown in Table 2-20, Sandwich's 1980 catch was 14.8 million pounds which was valued at 7.7 million.

Table 2-20

Fish Catch & Value, Massachusetts Ports, 1977-1980*

(Fish catch and value figures are in millions)

	1977		1978		1979		1980	
Port	Catch	Value	Catch	Value	Catch	Value	Catch	Value
Gloucester	150.9	21.5	185.4	28.9	160.2	29.7	210.0	34.7
New Bedford	75.5	43.2	71.9	54.6	86.0	67.4	99.6	71.3
Boston	22.2	6.0	27.3	8.1	30.3	10.7	34.4	12.3
Provincetown	17.9	6.9	19.9	9.1	23.4	10.3	25.8	10.4
Sandwich	16.1	5.3	19.0	7.8	19.1	10.7	14.8	7.7

*Sources: Fisheries of the United States, 1980, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, April 1981.

National Marine Fisheries Service, Resource Statistics Office, Northeast Fisheries Center, Woods Hole, Massachusetts, March 1982.

The period of most important growth for the fishing industry in Sandwich was the period 1975-1978. The number of fishing trips doubled, the catch tripled, and the value of the catch quadrupled. Table 2-21 shows the pounds and dollar value of fish landed at Sandwich from 1975 to 1980. In 1979, the catch only increased slightly, but the value of the catch incrased markedly as a result of the increase in the price of fin-fish.

Table 2-21

Reported Fish Landings, Sandwich, 1975-1980*

Year	Number of Trips	Number of Pounds	Increase Over Previous Year	Ex-Vessel Value	Increase Over Previous Year
1975	962	6,383,000	--	$ 1,573,000	--
1976	1,724	11,845,000	5,462,000 lbs. 86%	$ 4,359,000	$2,606,000 149%
1977	1,886	15,340,000	3,495,000 lbs. 30%	$ 5,045,000	$ 686,000 16%
1978	1,828	19,021,000	3,681,000 lbs. 24%	$ 7,778,000	$2,733,000 54%
1979		19,100,000	79,000 lbs. less than 1%	$10,700,000	$2,922,000 38%
1980	1,703	14,800,000	-4,300,000 lbs. -23%	$ 7,700,000	-$3,000,000 -28%

NOTE: Increase in pounds - 1975-1978 - 198%
Increase in dollar value - 1975-1978 - 344%

Source: Commonwealth of Massachusetts Division of Marine Fisheries, Sandwich

Table 2-22 shows how Sandwich landings are distributed between Sandwich based boats and non-Sandwich based boats for the year 1977, the only year for which this information is available. Data in Table 2-21 comes from a report entitled "An Economic Profile of the Cape and the Island Fisheries" prepared by the Cape Cod Planning and Economic Development Commission in 1978.

Table 2-22

1977 Landings in Sandwich

Home Port	Pounds Landed	%	Value of Landings	%
Sandwich	3,368,143	21.6	$1,558,495	28.4
Other Vessels	12,238,620	78.4	3,926,973	71.6
TOTALS	15,606,763	100.0	$5,485,463	100.0

Without expansion of the East Boat Basin, fishing activities and port utilization can be expected to continue about at the same levels as in the past. Growth in commercial fishing would be inhibited by constraints on space and absence of competitive marine services.

COMMERCIAL FISHING - WITH PROJECT CONDITION

The short term impact of an expansion of the basin would be in terms of transfer activity rather than new growth in vessels. Most transfers can be expected to come from New Bedford and Provincetown but would include other ports as well. A mix of some larger boats, but mostly small inshore vessels, which are weather dependent, would establish Sandwich as a home port. These boats will probably be engaged primarily harvesting flounder, cod and haddock, but also some whiting (silver hake), surf clams (sea clams) and ocean quahaugs. Extensive processing activities are not envisioned. The major need would be offloading in conjunction with icing and minor processing. The produce would then be shipped to secondary markets. Sandwich is, and most likely will continue to be principally engaged in serving transient vessels. Many boat skippers who seek a more stable pricing structure would prefer to unload in Sandwich in order to beat the New Bedford auction system. Also, there are fewer operating constraints in Sandwich compared to New Bedford.

When considering the long term growth horizon for the basin, there is some growth potential in traditional species (say 10-20%). New Bedford is expected to gain most of the new boats to be built for the ground fishery. Sandwich can be expected to gain a small fraction of these vessels. The real potential for growth lies with the non-traditional species which include surf clams, ocean quahaugs, herring, mackerel, silver hake and squid.

The surf clam and ocean quahaug fisheries represent industries with great growth potential. Both the resource availability and the market potential are excellent. Cape Cod Bay has abundant surf clam supplies which can support a year-round fishery, however the limits are not known. Howard Johnson's and other food chains constitute the lion's share of the market. Sandwich would be an ideal operating port for boats in the surf clam and ocean quahaug fisheries. National Marine Fisheries Service estimates a potential for a fleet of 25 such boats.

Herring is another species with growth potential. In the past it was used for reduction purposes but it is currently more valuable as food. Herring is a winter fishery (late November to March or April). This fishery presently operates out of Gloucester and Sandwich. It is estimated that in the winter Sandwich would probably attract 15-20 vessels engaged in herring fishing.

Some growth potential also exists for mackerel, silver hake and squid. Sandwich is not considered as a candidate for the scallop industry.

POTENTIAL AS A COMMERCIAL FISHING PORT

Much of the long term growth would be in small inshore type vessels. Those would be mostly 50 to 60-foot vessels but would include some in the 75 to 80-foot class. These boats would feed into the fresh food market.

They would probably not unload daily but only ice up daily and perhaps unload once a week. In this manner they will be better able to "play" the prices. Inshore vessels are being built with better capabilities in terms of gear and cold storage. Although impossible to predict the future, a reasonable growth assumption is that the Sandwich commercial fishing fleet would grow from the present level of 40, to about 80 over a period of say 10 years, then remain at or about that level to the end of the 50 year planning horizon.

There exists a demand for locating more offloading facilities in Sandwich, in conjunction with the projected increase in commercial fishing. There would be more primary buyers now if the Corps of Engineers would permit it. With an expansion of the East Boat Basin, the town of Sandwich could encourage the establishment of more offloading facilities. There is also potential for various ancillary services (e.g., marine supply, boat repair, restaurants, etc.).

The future of the fishing industry is dependent on more berthing space and more facilities becoming available. In particular, good port facilities are needed for products used locally in various areas. It is not considered sufficient merely to gear up New Bedford and Boston. Sandwich is a natural port for certain fishing operations discussed in the previous section. It is a year round virtually ice free port with ready access to open water. Also it would involve relatively low maintenance over time to keep commercial fishing activities operational.

COMMERCIAL FISHING BENEFITS

Commercial fishing benefits are generated by increased landings from new growth of the fleet, which is dependent upon the configuration constraints imposed by the particular expansion alternatives being considered. The local fishing fleet at Sandwich consists of about 40 boats. Table 2-23 summarizes the existing Sandwich-based fleet for both summer and winter seasons.

Table 2-23

Sandwich Based Fleet*

Type of Boat	Summer	Winter
Lobster	20	0
Trawler	18	29
Scallop	6	6
TOTALS	44	35

*Source: Harbormaster, East Boat Basin

The summer and winter seasons are assumed to each be of 6 months duration, with the lobster boats operating during the summer season only (they are now hauled out of the water in winter). The Sandwich fleet gains about 11 boats from other ports during the winter however. This includes trawlers, seiners and draggers. Some transfer from Plymouth, Point Judith, New Bedford and Provincetown when those harbors freeze. Some seiners from New Jersey come to Sandwich for about one month in the fall to fish for herring.

Based on the existing situation, it is strongly felt that one-half of any projected increases in the Sandwich based fleet presumably would be transfers from other ports. The existing transient fleet consists of boats that homeport in other ports as noted above, but find it extremely convenient to offload fish in Sandwich. Given the opportunity, it is felt that many of these vessels would homeport at Sandwich. No analysis is considered relative to these vessels since no net benefit to the nation will accrue unless an efficiency gain accompanies the transfer. As of now, no clear efficiency gain to these vessels has been documented.

In making projections of commercial fishing activity expected at an expanded East Boat Basin, heavy reliance was placed on public sources. This group included the National Marine Fisheries Service, the Massachusetts Division of Marine Fisheries, the local fish wholesalers, the fishermen and the Sandwich harbormaster. The projections were expressed in terms of future increases in fish landings and value resulting from growth in the fishing fleet. In each alternative plan, projected growth is dependent upon the configuration constraints imposed by that particular plan. In addition, one-half of all new boats are considered to be immediate transfers from other ports.

Prices for fish used in the analysis are average values received in Barnstable County for 1981, the latest available from the Resource Statistics Office of the National Marine Fisheries Service. Surf clams are valued at $1.00 per pound while the price of silver hake (whiting) at $.20 per pound is used as a typical value for non-traditional species. The average price for traditional groundfish was determined from the 1981 National Marine Fisheries Service listing of fish prices per pound for Barnstable County and known species caught by Sandwich fishermen including cod, flounder, haddock, pollock, etc. This average price is estimated to be $.40.

Benefit calculations for new boats under the different alternative plans are presented below.

Table 2-24 below provides the projected increases in the fishing fleet for each plan, for both the open-mooring (OM) condition and the slip berthing (SB) condition.

Table 2-24

Projected Increases in the Fishing Fleet

Plan	Transfer Boats* OM	Transfer Boats* SB	Surf Clam Boats OM	Surf Clam Boats SB	Ground Fish Vessels OM	Ground Fish Vessels SB	Non-Traditional Vessels OM	Non-Traditional Vessels SB	Total Increase OM	Total Increase SB
A	7	16	3	8	2	4	2	4	14	32
B	8	20	5	10	2	5	2	5	17	40
C	9	21	5	11	2	5	2	5	18	42
D	6	18	3	9	2	4	1	4	12	35

*Transfer boats do not contribute to the NED account.

A sample benefit calculation for Plan A is provided below. Annual benefits based on new landings were determined in the same manner for the remaining plans. In plans where less than 10 new boats were projected, not including transfers, the growth period was assumed to be 5 years. In plans projecting more than 10 new boats a 10 year growth period was assumed. Therefore the average annual equivalent factor varied depending upon the growth period. Table 2-25 provides a summary of average annual commercial fishing benefits for all plans.

PLAN A - Commercial Fishing Benefits

Projected Additions to Existing Fleet:

Open Mooring Option - 14 new vessels

7 Transfers

3 Surf Clam Boats

2 Ground Fish

2 Non-Traditional

Slip Option - 32 new vessels

16 Transfers

8 Surf Clam Boats

4 Ground Fish

4 Non-Traditional

Benefit Calculations:

Open Mooring Option:

3 Surf Clam Boats (3 boats x 1 landing/day x 240 days/
year x 3000 lbs/landing x $1.00 lb.) = $2,160,000

2 Ground Fish Vessel (2 boats x 2 landings/week x 35 weeks/year x 4000 lbs./landing x \$0.40/lb.) = \$224,000

2 Non-Traditional Boat (2 boats x 1 landing/week x 40 weeks/year x 75,000 lbs./landing x \$0.20/lb.) = <u>\$1,200,000</u>

Total (Ultimate) Gross Benefit \$3,584,000

It is assumed that the 7 transfer vessels would move into the basin almost immediately upon project completion and the 7 new boats would be added within a 5-year period. A constant rate of growth over a 5-year period, a 50-year project economic life and a discount rate of 8-1/8 percent are utilized to annualize the ultimate benefit below.

Average Annual Gross Benefit (\$3,584,000 x .86) = \$3,082,240

Slip Option:

8 Surf Clam Boats (8 boats x 1 landing/day x 240 days/year x 3000 lbs./landing x \$1.00 lb.) = \$5,760,000

4 Ground Fish Vessels (4 boats x 2 landings/week x
35 weeks/year x 4000 lbs./
landing x $0.40/lb.) = $ 448,000

4 Non-Traditional Vessels (4 boats x 1 landing/week
x 40 weeks/year x 75,000
lbs./landing x $0.20/lb.) = $2,400,000

Total (Ultimate) Gross Benefit	$8,608,000

It is assumed that the 16 transfer vessels will move into the basin almost immediately upon project completion and the 16 new boats will be added within a 10-year period. Since new growth is assumed for a 10-year period, the MEF becomes 0.72.

Average Annual Gross Benefit ($8,608,000 x .72)	$6,197,760

Table 2-25

Average Annual Commercial Fishing Benefits

Plans	Option	Gross Benefits	Benefits - Net of Operating Expenses
A	OM	$3,082,240	$1,387,000
	SB	$6,197,760	$2,789,700
B	OM	$4,320,640	$1,944,300
	SB	$7,747,200	$3,486,200
C	OM	$4,320,640	$1,944,300
	SB	$8,265,600	$3,719,500
D	OM	$2,566,240	$1,154,800
	SB	$6,716,160	$3,022,300

*Operating expenses estimated to be 55 percent for new boats.

CHARTER FISHING BOAT BENEFITS

The charter boat business is currently a small part of the commercial fishing activity in the basin. However, it is considered to have good potential for growth, especially under the with project condition Sandwich would be a very attractive port for increased charter boat operations due to its closeness to sport fishing grounds and good highway connections. It is more accessible by highway from the north and west than are most other Cape Cod ports. Charter boats are presently operating out of Orleans (Rock Harbor), Dennis, Barnstable, Wellfleet, etc.

Species caught by charter boats are high value fish and include bluefish, tuna and striped bass. Some of the catch is usually sold commercially and fetches up to $1.50 per pound. Tuna usually weighs in at 500 to 1,500 pounds and usually is claimed by the captain. Local sources feel that up to 10 charter boats could easily operate out of Sandwich and that a minimum of 50 pounds of fish per trip would be sold commercially and that the average season would be 60 to 90 days. A sampling of prices charged on boats of 40 to 50 feet in length varies from $10 to $20 per trip for adults and boats of that size carry an average group of 20 fishermen per trip.

Benefits for the addition of these types of boats to the basin fleet are shown in Table 2-26.

Table 2-26

Charter Boat Fishing Benefits

Plans	Option	No. of Boats	Average Users Per Boat	Total Users	Average* Annual Benefit
A	OM	3	20	60	$58,100
	SB	8	20	160	$154,800
B	OM	4	20	80	$77,400
	SB	10	20	200	$193,500
C	OM	4	20	80	$77,400
	SB	10	20	200	$193,500
D	OM	3	20	60	$58,100
	SB	9	20	180	$174,200

*Assumptions in computation: (1) 75 day season; (2) unit day value = $15.00; (3) 5 year growth period (n = 50, g = 5, i = 8-1/8%, AAEF = 0.86).

Sample computation for Plan A (OM):

60 total users x 75 days x $15.00 unit day value x 0.86 AAEF = $58,100

RECREATIONAL BOATING BENEFITS

The various plans of improvement would benefit the recreational fleet by providing the possibility for expansion. The unit-day value method for computing recreational boating benefits is chosen based on its simplicity ease of application, ability to measure increases in efficiency and the fact that improvements at the site will result in less than a 500,000 user day increase.

Existing Fleet

The town of Sandwich currently operates a recreational boating marina in the basin which provides 72 slips utilized by about 82 boats. Twelve slips are designated for transients resulting in a permanent home fleet of 70 boats, mostly power. Transient boats, mostly larger cruising sailboats (25+ feet) that cruise the New England and eastern U.S. coast, also use the basin extensively. These sailboats often moor in the open areas because of a lack of slips. On an average day about 15-20 transients may be at anchor in the basin in addition to 12 in slips. During peak holiday periods, up to 50 transients can be seen anchored in the basin. Conditions during these periods are extremely crowded. For purposes of computing an existing fleet, 30 transient cruising sailboats (12 in slips and 18 anchored) were added to the 70 home port boats in slips for a total of 100 boats. The existing fleet is summarized in Table 2-27 below.

Table 2-27

Existing Recreational Fleet

Type of Boat	Length	No. in Class	Average No. of Users Per Class	Total Users
Power	under 20'	19	2	38
	21' to 24'	15	3	45
	25' to 29'	10	4	40
	30' to 35'	10	5	50
	36' to 42'	9	6	54
	43' to 50'	7	6	42
Cruising Sail (transient)	25' to 40'	30	4	120
Total		100		389

Without-Project Condition Fleet

Since net recreational benefits are determined by comparing the with-project condition to the without-project condition, the without-project condition fleet had to be determined. The without-project condition fleet is summarized in Table 2-28 as developed in previous sections.

Table 2-28

Without-Project Condition Fleet

Type of Boat	Length	No. in Class
Power	under 20'	19
	21' to 24'	35
	25' to 29'	32
	30' to 35'	10
	36' to 42'	9
	43' to 50'	7
Cruising Sail	25' to 40'	30
Total		142

Future Fleet

The Sandwich Marina maintains a waiting list of boats that desire to obtain berthing space in the basin. Requests for space, which date back to 1973, now number 116 boats on active file. About 18 of these are sailboats ranging from 18-50 feet in length and the rest power. It was assumed in the benefit analysis that all waiting list boats would fill space immediately if given the opportunity.

Additional growth in the recreational fleet beyond the boats on the waiting list is also expected. It was assumed that recreational boating demand would increase with population growth. Therefore a 20-year projected average poulation growth rate for Barnstable County was applied to the combined permanent and waiting list fleet to project growth over a 10-year period after project construction.

Boat Use Days Per Season

The ideal number of days of use per season is based on a boating season on the Cape extending from early May to mid-October, about 165 days. Based on observed practices and traffic at southeastern Massachusetts marinas several assumptions have been made. Constraints of limited vacation time and inclement weather must be considered. It is estimated that each boat will only be used an average of 35 percent of the available season time or roughly 60 days. Actually, many of the larger boats with a longer range, particularly the cruising sailboats, take extended cruises and are absent from the harbor for periods of 2 to 14 days at a stretch. At the other end of the spectrum, smaller boats may be used less.

Unit Day Value

The unit day value is estimated in accordance with procedures contained in Appendix 3 to Subpart K of the WRC Manual. Recreational boating is considered to be "specialized recreation other than hunting and fishing." Point values were assigned for each criteria utilizing Table K-3-3, shown on Figure 2-2.

Criteria	Value
Recreation Experience	16
Availability of Opportunity	10
Carrying Capacity	11
Accessibility	16
Environmental Quality	16
TOTAL	69

The rating points are converted to dollar values by utilizing the conversion table (Revised Table K-3-1 - FY 1983) found in the WEC FY 1982 Reference Handbook and shown on Figure 2-3. Sixty-nine points represents a unit day recreation value of $12.80.

RATING POINT TABLE FOR RECREATION

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Table K-3 3 - Guidelines for Assigning Points for Specialized Recreation

Criteria	Judgment Factors				
a) Recreation Experience 8/	Heavy use or frequent crowding or other interference with use	Moderate use, other users evident and likely to interfere with use	Moderate use, some evidence of other users and occasional interference with use due to crowding	Usually little evidence of other users, rarely if ever crowded	Very low evidence of other users, never crowded
Total Points: 30 Point Value:	0-4	5-10	11-16	17-23	24-30
b) Availability of Opportunity 7/	Several within 1 hr. travel time; a few within 30 min. travel time	Several within 1 hr. travel time; none within 30 min. travel time	One or two within 1 hr. travel time; none within 45 min. travel time	None within 1 hr. travel time	None within 2 hr. travel time
Total Points: 18 Point Value:	0-3	4-6	7-10	11-14	15-18
c) Carrying Capacity 1/	Minimum facility development for public health and safety	Basic facilities to conduct activity(ies)	Adequate facilities to conduct without deterioration of the resource or activity experience	Optimum facilities to conduct activity at site potential	Ultimate facilities to achieve intent of selected alternative
Total Points: 14 Point Value:	0-2	3-5	6-8	9-11	12-14
d) Accessibility	Limited access by any means to site or within site	Fair access, poor quality roads to site; limited access within site	Fair access, fair road to site, fair access, good roads within site	Good access, good roads to site; fair access, good roads within site	Good access, high standard road to site; good access within site
Total Points: 18 Point Value:	0-3	4-6	7-10	11-14	15-18
e) Environmental Quality	Low esthetic factors 5/ exist that significantly lower quality 6/	Average esthetic quality; factors exist that lower quality to minor degree	Above average esthetic quality; any limiting factors can be reasonably rectified	High esthetic quality; no factors exist that lower quality	Outstanding esthetic quality; no factors exist that lower quality
Total Points: 20 Point Value:	0-2	3-6	7-10	11-15	16-20

1/ Value should be adjusted for overuse.

2/ Value for water-oriented activities should be adjusted if significant seasonal water level changes occur.

3/ General activities include those that are common to the region and that are usually of normal quality. This includes picnicking, camping, hiking, riding, cycling, and fishing and hunting of normal quality.

4/ High quality value activities include those that are not common to the region and/or Nation and that are usually of high quality.

5/ Major esthetic qualities to be considered include geology and topography, water, and vegetation.

6/ Factors to be considered in lowering quality include air and water pollution, pests, poor climate, and unsightly adjacent areas.

7/ Likelihood of success at fishing and hunting.

8/ Intensity of use for activity.

FIGURE-2-2

POINTS TO DOLLARS CONVERSION TABLE

Revised Table K-3-1 (FY 1983) Conversion of Points to Dollar Values

Activity Categories	POINT VALUES										
	0	10	20	30	40	50	60	70	80	90	100
General Recreation (Points from Table K-3 2)	1.60	1.90	2.10	2.40	3.00	3.40	3.70	3.90	4.30	4.60	4.80
General Fishing & Hunting (Points from Table K-3 2)	2.30	2.60	2.80	3.10	3.40	3.70	4.10	4.30	4.60	4.70	4.80
Specialized Fishing & Hunting (Points from Table K-3 3)	11.20	11.50	11.70	12.00	12.30	13.50	14.70	15.60	16.80	18.00	19.00
Specialized Recreation Other than Fishing & Hunting (Points from Table K-3 3)	6.50	6.90	7.40	8.00	8.50	9.60	10.60	12.80	14.90	17.00	19.00

NOTE: See 44 FR 72963-64 (published December 14, 1979) for Table K-3-2 and K-3-3.

FIGURE 2-3

Users Per Fleet

The number of boating users was determined by multiplying the average number of users per class of boat times the number of boats projected in each class. These are shown for the without-project condition and projected fleets under the with-project condition in the following sections.

Benefit Calculations

Having an established unit day recreation value of $12.80/day, an average use per boat of 60 days per season and the total boat users in the without-project and with-project fleets, the yearly value of recreational boating under each scenario can be computed. Net benefits are determined by subtracting the value computed for the without-project condition from the values computed for each of the several plans under the with-project condition.

Annual benefits were determined for both immediate growth and 10-year growth. The 10-year growth annual benefit was determined by multiplying the annual equivalent factor for a 10-year gradient, project life of 50 years and discount rate of 8-1/8 percent, by the ultimate annual benefit. The annual equivalent factor is .72. The immediate growth annual benefit and 10-year growth annual equivalent benefit were then added for a total annual benefit.

The breakdown of the without-project fleet and the with-project fleets (Plans, A, B, C and D) and the numbers of boat users resulting from each are shown below in Tables 2-29 and 2-30.

Table 2-29

Without-Project Condition Fleet

and Boat Users

Type of Boat	Length	No. in Class	Average No. of Users Per Class	Total Users
Power	under 20'	19	2	38
	21' to 24'	35	3	105
	25' to 29'	32	4	128
	30' to 35'	10	5	50
	36' to 42'	9	6	54
	43' to 50'	7	6	42
Cruising Sail (transients)	25' to 40'*	30	4	120
Total		142		537

*Transient boats are generally crusing sailboats of 25 to 40 feet in length. There is now existing capacity for 42 of these - 12 in slips and 30 anchored. At any given time during the season, however, an average of 30 will be found in the basin.

Table 2-30

With-Project Projected Fleet (Wet Storage) and Boat Users

Type of Boat	No. in Class Immed	No. in Class 10-Yr	No. of Users	Total Users Immed	Total Users 10-Yr
			Plan A		
under 25'	54	0	2 and 3	143	0
25' to 29'	32	0	4	128	0
30' to 35'	11	0	5	55	0
36' to 42'	9	0	6	54	0
43' to 50'	7	0	6	42	0
Cruising Sail	30	0	4	120	0
	143			542	
			Plan B		
under 25'	54	1	2 and 3	143	0
25' to 29'	32	6	4	128	24
30' to 35'	20	4	5	100	20
36' to 42'	12	2	6	72	12
43' to 50'	11	2	6	66	12
Crusing Sail	30	0	4	120	0
	159	15		629	71
			Plan C		
under 25'	54	0	2 and 3	143	0
25' to 29'	32	0	4	128	0
30' to 35'	19	0	5	95	0
36' to 42'	12	0	6	72	0
43' to 50'	10	0	6	60	0
Cruising Sail	30	0	4	120	0
	157			618	
			Plan D		
under 25'	54	4	2 and 3	143	12
25' to 29'	32	14	4	128	56
30' to 35'	20	8	5	100	40
36' to 42'	12	5	6	72	30
43' to 50'	11	5	6	66	30
Cruising Sail	30	0	4	120	0
	159	36		629	168

Table 2-30 summarizes only the growth in wet storage boats, not rack storage boats. It was assumed that the town would provide a 120-boat rack storage facility to absorb the projected growth in small boats. Rack storage boat benefits would not be applicable to justification of the recreational berthing area, and were therefore not included in the benefit analysis. The total projected growth including rack storage boats can be determined from Table 2-19.

The net annual recreational benefit calcaulations are summarized in Table 2-31.

Sample benefit calculations are presented below.

WITHOUT PROJECT CONDITION BENEFIT

Average amount of boating days per season	=	60
Recreator user days in fleet	=	537
Unit-day value for specialized recreation	=	$12.80
Total value of without project recreation (60 x 537 x $12.80)	=	$412,400

Table 2-31

Annual Recreation Benefits

	Gross Benefits	Net Benefits*
Without Project	$412,400	
Plan A	$416,300	$ 3,900
Plan B	$522,400	$110,000
Plan C	$474,600	$ 62,200
Plan D	$576,200	$163,800

*Net benefits is the difference between the without-project and each of the plans.

SUMMARY OF BENEFITS

Table 2-32 provides a summary of all annual benefits attributable to all the alternatives, for both the open mooring and slip berthing conditions in the commercial berthing area.

Table 2-32

Summary of Annual Benefits

		Commercial Fishing	Recreational Boating	Charter Fishing	Total
A	OM	$1,387,000	$ 3,900	$ 58,100	$1,449,000
	SB	$2,789,700	"	$154,800	$2,948,400
B	OM	$1,944,300	$110,000	$ 77,400	$2,131,700
	SB	$3,486,200	"	$193,500	$3,789,700
C	OM	$1,944,300	$ 62,200	$ 77,400	$2,083,900
	SB	$3,719,500	"	$193,500	$3,975,200
D	OM	$1,154,800	$163,800	$ 58,100	$1,376,700
	SB	$3,022,300	"	$174,200	$3,360,300

ECONOMIC JUSTIFICATION

To be considered economically justified, a project must have a benefit cost ratio of one or greater. The ratios for the alternatives at East Boat Basin - Plans A, B, C, and D, both open mooring and slip berthing options - are displayed in Table 2-33. The Plan and option that maximizes net benefits (total benefits minus costs) is Plan C, Slip Berthing option.

Annual costs shown in Table 2-33 are derived from detailed first construction costs shown in Section 1 of Supporting Documentation. Total investment costs were computed by adding the cost of Interest During Construction calculated in conformance with the Planning Guidance Notebook (EP 1105-2-45, paragraph 2-6, page 2-2) and the NED Manual (Sections 713-25 and 713.2007b) to first construction costs. Construction of all plans is estimated to take approximately two years. The estimate of annual costs is based on a 50-year project life and an interest rate of 8-1/8 percent (also used for interest during construction). Annual costs also include expenditures projected for annual maintenance and the economic cost of land required for the proposed project. Land value was estimated at $45,000/acre, which was multiplied by the number of acres for each plan and added in with the total investment costs.

A sample annual cost computation, including interest during construction, is shown below.

Plan C Slip Berthing Option

First Construction Cost (including land) = $9,655,000

Investment cost = (4,827,500 x 1.03983*) + (4,827,500 x 1.12432*) =

$10,447,000

IDC = $792,000

Annual Cost = $10,447,000 x .0829 = $866,000

With maintenance of $18,000, Annual Cost = $884,000

* Single Payment Compound Amount Factor at 8-1/8% for .5 and 1.5 years.

Table 2-33

Economic Justification (in 000's)

Plans		Annual Benefits	Annual Costs	BCR	Net Benefits
A	OM	$1,449	$718	2.0	$731
	SB	$2,948	$770	3.8	$2,178
B	OM	$2,132	$994	2.2	$1,138
	SB	$3,790	$1,059	3.6	$2,731
C	OM	$2,084	$816	2.6	$1,268
	SB	$3,975	$884	4.5	$3,091
D	OM	$1,377	$972	1.4	$405
	SB	$3,360	$1,037	3.2	$2,323

APPORTIONMENT OF COSTS

The apportionment of project costs plays an important part in decisions made by local interests concerning their desire and ability to construct a project. Therefore, this section of the supporting documentation provides an analysis of what the expected cost apportionment would be for each alternative plan, with disposal at the Foul Area.

COST ALLOCATION

The purpose of cost allocation is to provide an equitable distribution of project costs among the project purposes. Cost allocation is particularly important in projects where the entire project, or a portion of the project is multiple use. The proposed East Boat Basin expansion project would be considered a multiple-use project; however, several project features address specific purposes, while other project features serve multiple uses. The cost of project features addressing specific purposes would be entirely allocated to that feature. However, the allocation of multiple-use project feature costs would require distribution of the costs between the various purposes. This is important because Federal cost-sharing policies are based on, and vary with, the types of purposes that a project addresses. Costs for multiple-use facilities are allocated using a systematic approach as prescribed by guidance provided in the U.S. Army Corps of Engineers' Planning Guidance Notebook. The specific guidance consulted is contained in EP 1105-2-45, chapter 3, Cost Allocations, Appendix A, Section IV.

Project Features

The proposed navigation project would include the following project features; entrance channel, turning/maneuvering area, commercial berthing area, recreational berthing area, offloading area, bulkhead and upland costs. The following sections delineate the cost of each project feature.

Entrance Channel - The entrance channel cost includes the cost of material removal and the cost of basin entrance modification. The material removal cost was determined by multiplying the dredging quantity for the entrance channel by the apropriate unit cost.

Turning/maneuvering Area. The turning/maneuvering area cost includes only the cost of material removal. Material removal costs were determined in the same manner as for the entrance channel.

Commercial Berthing Area - The commercial berthing area costs include the cost of material removal and the cost of slope protection. Material removal cost was determined as for previously discussed features. The slope protection cost was determined by multiplying gravel bedding and stone protection quanitities by the appropriate unit costs.

Recreational Berthing Area - The recreational berthing area costs were determined in the same manner as for the commercial berthing area.

Offloading Area - The offloading area costs were determined in the same manner as the turning/maneuvering area.

Bulkhead - Bulkhead costs include only the cost of bulkhead in and around the offloading areas, and not the bulkhead proposed for the basin entrance modification, which is included in the entrance channel cost. Bulkhead cost was determined by multiplying the lineal feet of bulkhead by the unit cost.

Upland Costs - Upland costs include road relocation, utility relocation demolition, and topsoil and seed

The following Table 2-34 summarizes the estimated costs of project features and the total project first cost for alternative plans, with disposal at the Foul Area.

Table 2-34

Project Feature Costs (in 000's)

Feature	Plan A	Plan B	Plan C	Plan D
Entrance Channel	$ 600	$ 552	$ 759	$ 675
Turning/maneuvering area	580	526	641	274
Commercial berthing area	998	1,763	1,276	1,772
Recreational berthing area	401	710	484	622
Offloading area	142	135	147	155
Bulkhead	2,262	3,190	2,262	3,045
Upland costs	90	93	93	95
Subtotal	$5,073	$6,969	$5,662	$6,638
Contingencies (20%)	1,015	1,394	1,132	1,328
Subtotal	$6,088	$8,363	$6,794	$7,966
E&D (7%)	426	585	476	558
S&A (7%)	426	585	476	558
Total*	$6,940	$9,533	$7,746	$9,082

*Total cost may vary slightly due to rounding.

Cost Allocation of Project Features

The proposed expansion would include project features that address specific purposes and multiple purposes. Two project features were identified as being multiple purpose, the entrance channel and the turning/maneuvering area, and therefore allocation of their costs to the appropriate uses is required. The remaining project features costs can be attributed to specific purposes.

Cost allocation of multiple purpose project features was performed by determining the remaining benefits that would accrue to the two specific purposes (features), and allocating cost based on the proportion of single purpose excess benefit to total excess benefit. Benefits attributable to each purpose were based on the new and existing boats that would utilize the expanded recreational and commercial portions of the project. The steps used to perform this process are outlined below.

1. Annual benefits for each specific purpose (feature) recreational boating and commercial fishing, were determined.

2. The annual cost for each specific project feature that would generate the associated annual benefit was determined.

3. The annual benefits and annual costs were compared for each purpose, and excess benefits determined for each single purpose and the total of single purposes.

4. The proportions of single purpose excess benefit to total excess benefit was applied to the multiple purpose features for allocation of costs.

Two possible cost allocations were determined based on the type of mooring scheme used in the commercial area. This is because the type of mooring scheme affects the level of benefits, and therefore the amount of excess benefits. The two cost allocation scenarios are summarized in Table 2-35 and 2-36 below.

Table 2-35

Cost Allocation - Open Mooring

	Commercial		Recreational		
Plan	Excess Benefit	%	Excess Benefit	%	Total
A	$1,331,900	95.8	$58,200	4.2	$1,390,100
B	$1,821,800	94.8	$100,700	5.2	$1,922,500
C	$1,877,000	95.2	$94,100	4.8	$1,971,100
D	$1,155,900	88.7	$147,600	11.3	$1,303,500

Table 2-36

Cost Allocation - Slip Berthing

Plan	Commercial Excess Benefit	%	Recreational Excess Benefit	%	Total
A	$2,941,900	98.1	$58,200	1.9	$3,000,100
B	$3,723,100	97.4	$100,700	2.6	$3,823,800
C	$3,961,600	97.7	$94,100	2.3	$4,055,700
D	$3,417,400	95.9	$147,600	4.1	$3,565,000

The cost of the entrance channel and the turning/maneuvering area would be allocated between commercial fishing and recreational boating purposes based on the percentages contained in the above tables.

COST APPORTIONMENT

The Federal Government can participate in navigation projects based on the cost-sharing policies as formulated by the Congress and/or the Executive Branch. Considering the uncertainity of cost-sharing policies at this time, three cost-sharing scenarios were analyzed, including traditional policies, cost-sharing based on existing authority and cost-sharing policies proposed by the administration. The cost-sharing policies proposed by the administration are addressed in the Feasibility

Report. Analyses of the two remaining cost-sharing methods are contained herein.

Traditional Cost-Sharing

Traditional cost-sharing guidance was obtained by consulting Chapter 2, Navigation, contained in ER 1105-2-20 of the Planning Guidance Notebook. Cost-sharing guidance pertaining to the proposed navigation project is summarized in Table 2-37 below. The percentages given address only construction of the navigation feature and not the cost of slips, which is always a local cost.

Table 2-37

Traditional Cost-Sharing

	Cost-Sharing	
Item	Federal	Non-Federal
Commercial navigation	100%	0%
Recreational navigation	50%	50%
Mooring basin	100%	0%
Berthing areas*	0%	100%
Bulkheading	0%	100%
Upland facilities	0%	100%

* Berthing areas include areas utilizing slips and areas for offloading vessels.

The above cost-sharing percentages were used to obtain the final cost-share of each project feature.

Entrance Channel - The bulkhead portion of the entrance channel cost would be a local cost ($282,000, not including contingencies, E&D, S&A) representing 47.0, 51.1, 37.2, and 41.8 percent of the entrance channel cost for Plans A, B, C, and D. The remaining percentage of the entrance channel cost was allocated based on Tables 2-35 and 2-36. Tabel 2-38 summarizes the allocation of entrance channel costs.

Table 2-38

Allocation of Entrance Channel Costs (in %)

			Channel Construction			
		Channel	Commercial		Recreational	
Plan	Bulkhead	Construction	OM	SB	OM	SB
A	47.0	53.0	50.8	52.0	2.2	1.0
B	51.1	48.9	46.4	47.6	2.5	1.3
C	37.2	68.8	59.8	61.4	3.0	1.4
D	41.8	58.2	51.6	55.8	6.6	2.4

Entrance channel costs were apportioned based on the cost-sharing percentages contained in Table 2-37. The cost-sharing percentages were applied to the cost-allocation percentages to determine the Federal and non-Federal cost-share contained in Table 2-39.

Table 2-39

Entrance Channel Cost-Sharing (in %)

	Federal		Non-Federal	
Plan	OM	SB	OM	SB
A	51.9	52.5	48.1	47.5
B	47.7	48.3	52.3	51.7
C	61.3	62.1	38.7	37.9
D	54.9	57.0	45.1	43.0

Turning/Maneuvering Area - Cost apportionment percentages were applied to the cost allocation percentages of Tables 2-35 and 2-36 to obtain cost-sharing as summarized in Table 2-40.

Table 2-40

Turning/Maneuvering Area Cost-Sharing (in %)

Plan	Federal OM	Federal SB	Non-Federal OM	Non-Federal SB
A	97.9	99.1	2.1	0.9
B	97.4	98.7	2.6	1.3
C	97.6	98.9	2.4	1.1
D	94.4	98.0	5.6	2.0

Commercial Berthing Area - This specific purpose feature would be a Federal cost entirely under the open mooring condition, and a local cost entirely under the slip berthing condition.

Recreational Berthing Area - Since this specific purpose feature is proposed to contain slip berthing for all conditions, it would be a local cost in all instances.

Offloading Area, Bulkhead, Upland Facilities - These specific features would all be a local cost.

The following table summarizes the traditional cost-sharing for Plans A, B, C, and D, for the navigation project and both mooring/berthing conditions.

Table 2-41

Traditional Apportionment of Project Costs (in 000's)

Plan A

Item	Open Mooring Federal	Open Mooring Local	Slip Berthing Federal	Slip Berthing Local
Entrance Channel	$311	$289	$315	$285
Turning/maneuvering area	568	12	575	5
Commercial berthing area	998	0	0	998
Recreational berthing area	0	401	0	401
Offloading area	0	142	0	142
Bulkhead	0	2,262	0	2,262
Upland costs	0	90	0	90
Subtotal	$1,877	$3,196	$890	$4,183
Contingencies (20%)	375	639	178	837
Subtotal	$2,252	$3,835	$1,068	$5,020
E&D (7%)	158	268	75	351
S&A (7%)	158	268	75	351
Total	$2,568	$4,371	$1,218	$5,722
Percentage	37.0%	63.0%	17.6%	82.4%

Plan B

Item	Open Mooring Federal	Open Mooring Local	Slip Berthing Federal	Slip Berthing Local
Entrance Channel	$263	$287	$267	$285
Turning/maneuvering area	512	14	519	7
Commercial berthing area	1,763	0	0	1,763
Recreational berthing area	0	710	0	710
Offloading area	0	135	0	135
Bulkhead	0	3,190	0	3,190
Upland costs	0	93	0	93
Subtotal	$2,538	$4,429	$786	$6,183
Contingencies (20%)	508	886	157	1,237
Subtotal	$3,046	$5,315	$943	$7,420
E&D (7%)	213	372	66	519
S&A (7%)	213	372	66	519
Total	$3,472	$6,059	$1,073	$8,458
Percentage	36.4%	63.6%	11.3%	88.7%

Plan C

Item	Open Mooring Federal	Open Mooring Local	Slip Berthing Federal	Slip Berthing Local
Entrance Channel	$465	$294	$471	$288
Turning/maneuvering area	626	15	634	7
Commercial berthing area	1,276	0	0	1,276
Recreational berthing area	0	484	0	484
Offloading area	0	147	0	147
Bulkhead	0	2,262	0	2,262
Upland costs	0	93	0	93
Subtotal	$2,367	$3,295	$1,105	$4,557
Contingencies (20%)	473	659	221	991
Subtotal	$2,840	$3,954	$1,326	$5,468
E&D (7%)	199	277	93	383
S&A (7%)	199	277	93	383
Total	$3,238	$4,508	$1,512	$6,234
Percentage	41.8%	58.2%	19.5%	80.5%

Plan D

Item	Open Mooring Federal	Open Mooring Local	Slip Berthing Federal	Slip Berthing Local
Entrance Channel	$371	$304	$585	$290
Turning/maneuvering area	259	15	269	5
Commercial berthing area	1,772	0	0	1,772
Recreational berthing area	0	622	0	622
Offloading area	0	155	0	155
Bulkhead	0	3,045	0	3,045
Upland costs	0	95	0	95
Subtotal	$2,402	$4,236	$ 654	$5,984
Contingencies (20%)	480	847	131	1,197
Subtotal	$2,882	$5,083	$785	$7,181
E&D (7%)	202	356	55	503
S&A (7%)	202	356	55	503
Total	$3,286	$5,795	$895	$8,187
Percentage	36.2%	63.8%	9.9%	91.1%

Existing Authority Cost-Sharing

Congressional authorization for construction of the 1963 basin expansion recommended that marina type slips be implemented by local interests, after construction of the expansion by the Federal Government. The following excerpt from House Document 168, dated February 27, 1957, is quoted from page 31 of the document.

> "In order to provide the maximum use of available anchorage area, and in order that the Federal improvement may be fully enjoyed by all citizens, local interests should be required to construct a marina in the 8-foot anchorage area capable of providing adequate facilities for prospective increases in the permanent and transient recreational fleets."

The present marina situation in the existing basin may provide a precedent concerning Federal cost-sharing in the recreational portion of the proposed expansion project. In other words, the Federal Government could possibly cost-share 50 percent of the construction cost for the recreational berthing area, depending upon interpretations by higher authority. Local interest would still be required to provide the slips.

Implementation of the precedent into the cost-sharing would have minimal impact since the cost of constructing the recreational berthing area is a relatively small percentage of the total project. The impact on cost-sharing was analyzed below in Tables 2-42 and 2-43 for comparison with traditional cost-sharing results.

Table 2-42

Apportionment Based on Precedent - Cost (in 000's)

Plan	Open Mooring Federal	Open Mooring Local	Slip Berthing Federal	Slip Berthing Local
A	$2,842	$4,097	$1,492	$5,448
B	$3,958	$5,573	$1,564	$7,977
C	$3,569	$4,177	$1,843	$5,903
D	$3,711	$5,370	$1,320	$7,762

Table 2-43

Apportionment Based on Precedent-Percent

Plan	Open Mooring Federal	Open Mooring Local	Slip Berthing Federal	Slip Berthing Local
A	41.0	59.0	21.5	78.5
B	41.5	58.5	16.4	83.6
C	46.1	53.9	23.8	76.2
D	40.9	59.1	14.5	85.5